DOCUMENT RESUME

ED 162 819 SE 025 016

AUTHOR	Clarkson, W. W.; And Others
TITLE	Land Application of Wastes: An Educational Program. Site Evaluation - Module 2, Objectives, Script, and Sources of Information.
INSTITUTION	State Univ. of New York, Ithaca. Coll. of Agriculture and Life Sciences at Cornell Univ.
SPONS AGENCY	Corps of Engineers, Washington, D.C.; Environmental Protection Agency, Washington, D. C.
PUB DATE	Jan 78
GRANT	EPA-T-900500
NOTE	75p.; For related documents, see SE 025 014-035; Not available in hard copy due to copyright restrictions; Contains occasional light and broken type
AVAILABLE FROM	Van Nostrand Reinhold, 450 West 33rd Street, New York, N.Y. 10001 (no price quoted)
EDRS PRICE	MF-$0.83 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Environment; *Geology; *Instructional Materials; *Land Use; *Learning Modules; Postsecondary Education; Sanitation; *Soil Science; *Waste Disposal; Wastes
IDENTIFIERS	Land Application; *Waste Water Treatment

ABSTRACT

This module describes important criteria to use in evaluating land for waste treatment sites and tells where the necessary information for such evaluation can be obtained. Among the important criteria for evaluation are climate, land use of potential site and surrounding areas, topography, drainage characteristics, soil properties, and geology. Climatic data are available for most locations in the United States in monthly and 10-year summaries. Computer programs can be obtained which identify unfavorable and favorable days for waste application in both wet and cold climates. Planning agencies on the local, regional and state level have information on land use. Topographic maps, information or water levels and water quality, and local groundwater conditions are available from U.S. and state geological surveys. Modern soil surveys published since 1960 provide a wealth of data in addition to soil physical properties. Aerial photos show land use, drainage, and topography of the land. (Author/BB)

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Land Application of Wastes

An Educational Program

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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SITE EVALUATION

Module 2

January, 1978

SE 025 016

LAND APPLICATION OF WASTES - AN EDUCATIONAL PROGRAM

The objective of this program is to increase the knowledge of engineers, scientists, waste management specialists and other practitioners in the concepts and principles needed to properly utilize the potential of land for the application of wastes. It is designed for individuals concerned with waste disposal alternatives for municipal, industrial, and agricultural wastes. The modules in this Program incorporate knowledge from sanitary and environmental engineering, agronomy, soil science, agricultural engineering, economics, and law.

The program consists of some twenty-five modules and audio-visual materials as appropriate.

Questions about the Program can be directed to:

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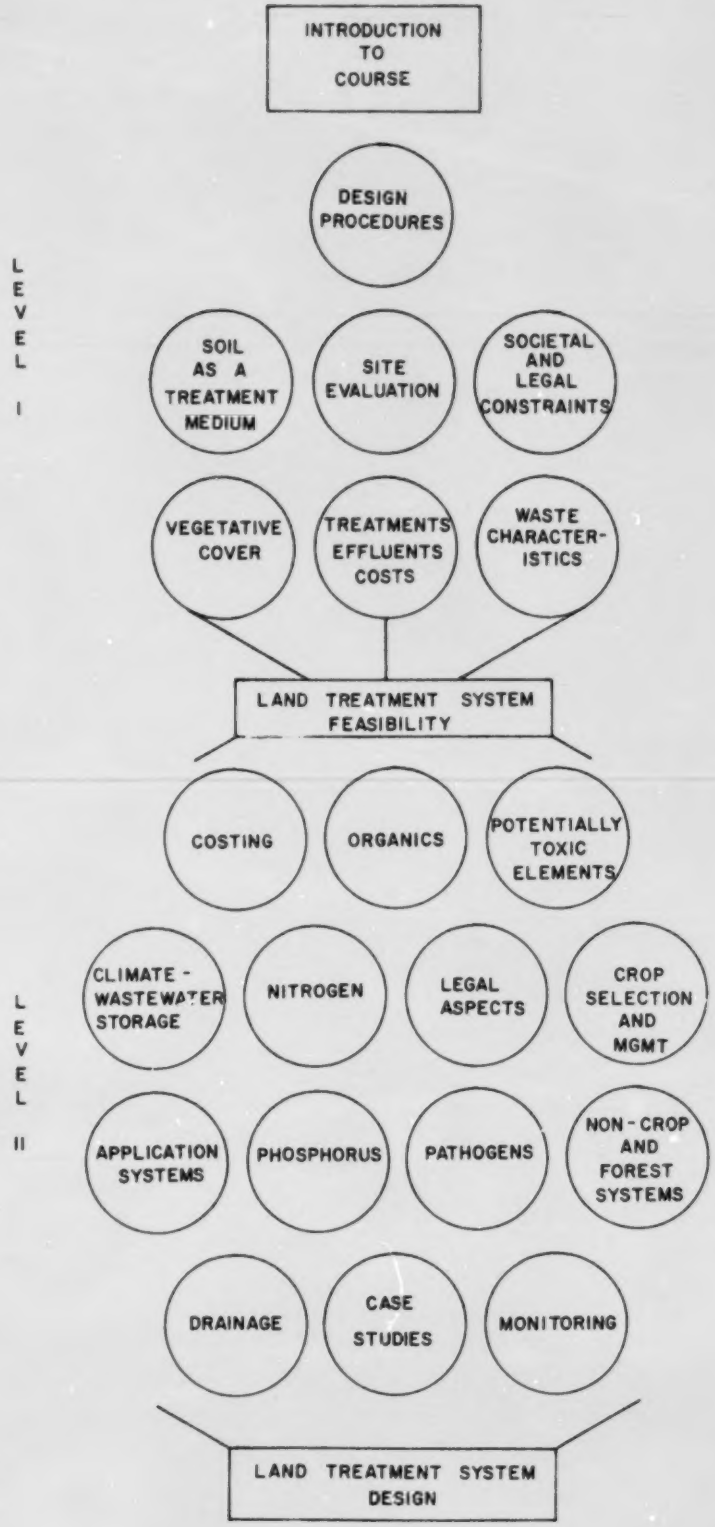

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SITE EVALUATION

Module 2

January, 1978

Summary

This module describes important criteria to use in evaluating land for waste treatment sites and tells where the necessary information for such evaluation can be obtained. Among the important criteria for evaluation are climate, land use of potential site and surrounding areas, topography, drainage characteristics, soil properties, and geology. Climatic data are available for most locations in the United States in monthly and 10-year summaries. Computer programs can be obtained which identify unfavorable and favorable days for waste application in both wet and cold climates. Planning agencies on the local, regional and state level have information on land use. Topographic maps, information on water levels and water quality, and local groundwater conditions are available from U.S. and state geological surveys. Modern soil surveys published since 1960 provide a wealth of data in addition to soil physical properties including: potential of land for farm use, potential of land for non-farm uses, dominant soil types, varying surface textures of soils, degree of slope and erosion of various soils, and engineering applications of the land. Soil surveys also give general features of the region such as population, drainage, major industries, and water supply. Aerial photos, a complementary source of information, show land use, drainage, and topography of the land.

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Glossary

The following terms are underlined when they appear in the text of this module.

lithology - the description of the physical character of a rock as determined by eye or with a low-grade magnifier, and based on color, structures, mineralogic compounds, and grain size.

permeability - the rate at which gases or liquids penetrate or pass through a bulk mass of soil or a layer of soil.

porosity - the volume percentage of the total bulk not occupied by solid particles.

sinkhole - a natural depression in a land surface, communicating with a subterranean passage, generally occurring in limestone regions and formed by solution or by collapse of a cavern roof.

soil association - a group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region.

soil complex - a mapping unit used in detailed soil surveys where two or more defined taxonomic units are so intimately intermixed geographically that it is undesirable or impractical, because of the scale being used, to separate them. This is a more intimate mixing of smaller areas of individual taxonomic units than that described under soil associations.

soil phase - basic mapping unit on detailed soil surveys where soil types are further characterized by slope, erosion or some other feature which affects their use.

soil series - the basic unit of soil classification, being a subdivision of a family and consisting of soils that are essentially alike in all major profile characteristics.

soil survey - the systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to the kind and intensity of field examination.

soil type - the lowest unit in the natural system of soil classification; a subdivision of a soil series and consisting of or describing soils that are alike in all characteristics including texture of the A horizon.

stereoscope - an optical instrument containing two eyepieces used to impart a three-dimensional effect to two photographs of the same scene taken at slightly different angles.

Glossary (cont.)

transmissibility - usually called transmissibility coefficient, the number of gallons of water per day that percolates through each square mile of water-bearing bed for each foot thickness of bed.

undifferentiated units - delineations on a detailed soil survey map that consist of two or more soil types or phases that have been grouped together because of similarities of properties and management needs. The pattern and proportion of these units are not uniform. The units are named for dominant soils.

Objectives

Upon completion of this module, the participant should be able to:

1. List the general categories of information which can be found in a soil survey that relate to evalution of a waste treatment site.
2. Describe the general climatic conditions in his zone of the United States.
3. List the sources of topographic maps and hydrogeologic studies and describe how to apply the information contained therein.
4. Summarize the criteria discussed in this module by which a potential site is judged.

Introduction

The feasibility of land application and treatment of wastes rests on no single consideration but rather on the integration of many. Among these are the kind, amount, and characteristics of the water, applicable laws and regulations, economic and socio-political factors, and characteristics of the land area itself. This module is directed to evaluating the land area.

Since this module was developed at Cornell University in upstate New York, the examples of soil surveys, soil types, and other data are taken from the State of New York. The complete Soil Survey of Monroe County is included as part of this module. It is suggested that the examples and data could be changed to adapt to the particular region in which the module is being used, since the purpose of examples is to increase understanding by referring to the familiar.

Evaluation Criteria

Climate Affects Feasibility, Design of Site

Localized areas provide little choice with respect to climatic conditions. Nevertheless, climate strongly affects the overall feasibility as well as the ultimate design of land treatment systems.

Temperature, moisture have profound effects on waste decomposition, growth of vegetative cover.

Suitable temperature and moisture conditions are necessary for organic waste decomposition and for growth and development of vegetative cover, key factors in most successful land treatment operations. Low temperatures reduce biological activity and thereby reduce the potential for waste renovation. Prolonged wet periods also impair renovation because saturation affects aeration, and the likelihood of surface runoff is increased. The net effect of unfavorable temperature and moisture conditions is that waste storage is required during a portion of the year. Broad relationships between climate and waste application systems are shown in a generalized climatic map in Figure 1 (Pound and Crites, 1973). The depicted zones are useful for preliminary planning, but ordinarily a detailed analysis of localized climatological data is necessary for design purposes.

Zone A has a history of using land application for treating wastes.

Zone A, covering much of California, has a marked seasonal pattern of precipitation. Average annual precipitation is about 15 to 25 inches, confined generally to the six-month period from November through April. At low elevations, temperatures are mild in winter and hot in summer so that with irrigation, plant growth can continue throughout the year. Storage of effluent during cold periods is not required, but may be desirable since crops in winter need less irrigation than in summer. Because water shortages are common in this area, wastewater application offers considerable potential for groundwater recharge and crop irrigation. Some ongoing land application systems date back to 1900 in this region.

Zone B covers the southwestern region of very hot, arid climates. Winter storage of effluent is not a major concern. This may vary locally, however, according to

changes in elevation. Land application of wastes will no doubt play an increasingly important role in this region.

Because Zone B is arid, land application will play an important role as a source of reclaimed water.

Zone C includes the mid and deep South as well as parts of Washington and Oregon. In the South, precipitation is distributed throughout the year, with hot, humid summers and fairly mild winters.

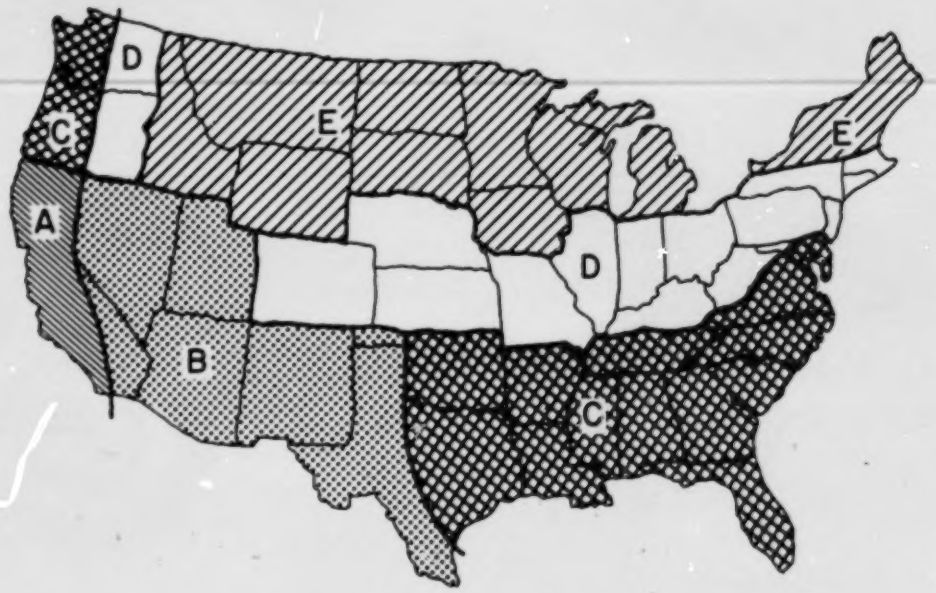


FIGURE 1. The United States is divided into five general climate zones useful for preliminary planning of land application. (after Pound and Crites, 1973)

Precipitation generally varies from 40 to 60 inches during the year; average daily temperatures range from the low 40's in winter to the low 80's in summers. Twelve month operation of land application systems is possible in many areas of the zone, although high precipitation may limit operation for short periods.

Zone C is suitable for year-round land application. Precipitation usually determines storage requirements.

Zone D covers eastern Washington and Oregon and the central tier of states. This area has moderately cold winters, with temperatures in the 20's and 30's, and hot summers,

Zone D requires effluent storage of up to 3 months.

with temperatures in the mid-70 range. Precipitation is generally well distributed throughout the year. Winter conditions are such that effluent storage will often be required for up to 3 months.

Zone E covers the northernmost tier of states. Precipitation occurs in all months of the year and averages from 20 to 40 inches annually. Winter operations are severely limited due to low temperatures, ice, and snow. There are some examples of long-term sites operating year-round in this zone, but storage may be necessary for 6 months or more. Although this is an added concern, it is not as restrictive economically as might be expected. Data on the costs of storage can be found in Module 10 "Costing Land Application Systems".

Severe winters in Zone E can require 6 months of storage or more.

Conservation Inventory Combines Climate with Other Factors

Figure 2 and Table 1 are excerpted from the USDA Soil Conservation Service booklet "2/3 of Our Land: A National Inventory" (1971). This pamphlet describes a Conservation Needs Inventory (CNI) of all privately owned rural land in the U.S., focusing on the percentage of tillable land; acreage of land use for crops, pasture, range, forest, etc.; and acreage requiring conservation measures.

The pamphlet describes how to get information for a county, conservation district, watershed, or other local area. The engineer can request any of the following from the local or county office of the Soil Conservation Service or from his conservation district office:

-- summary of Conservation Needs Inventory data for a county

-- county publications based on Inventory data or special interpretations of the data

-- soil survey of a county if available

--other soil, water, and plant information

The pamphlet also describes how to get information on a multicounty area, a state, a group of states, a multistate region or the mainland United States; for a river basin, a resource conservation and development project area, a planning district, or other area. This can be obtained by

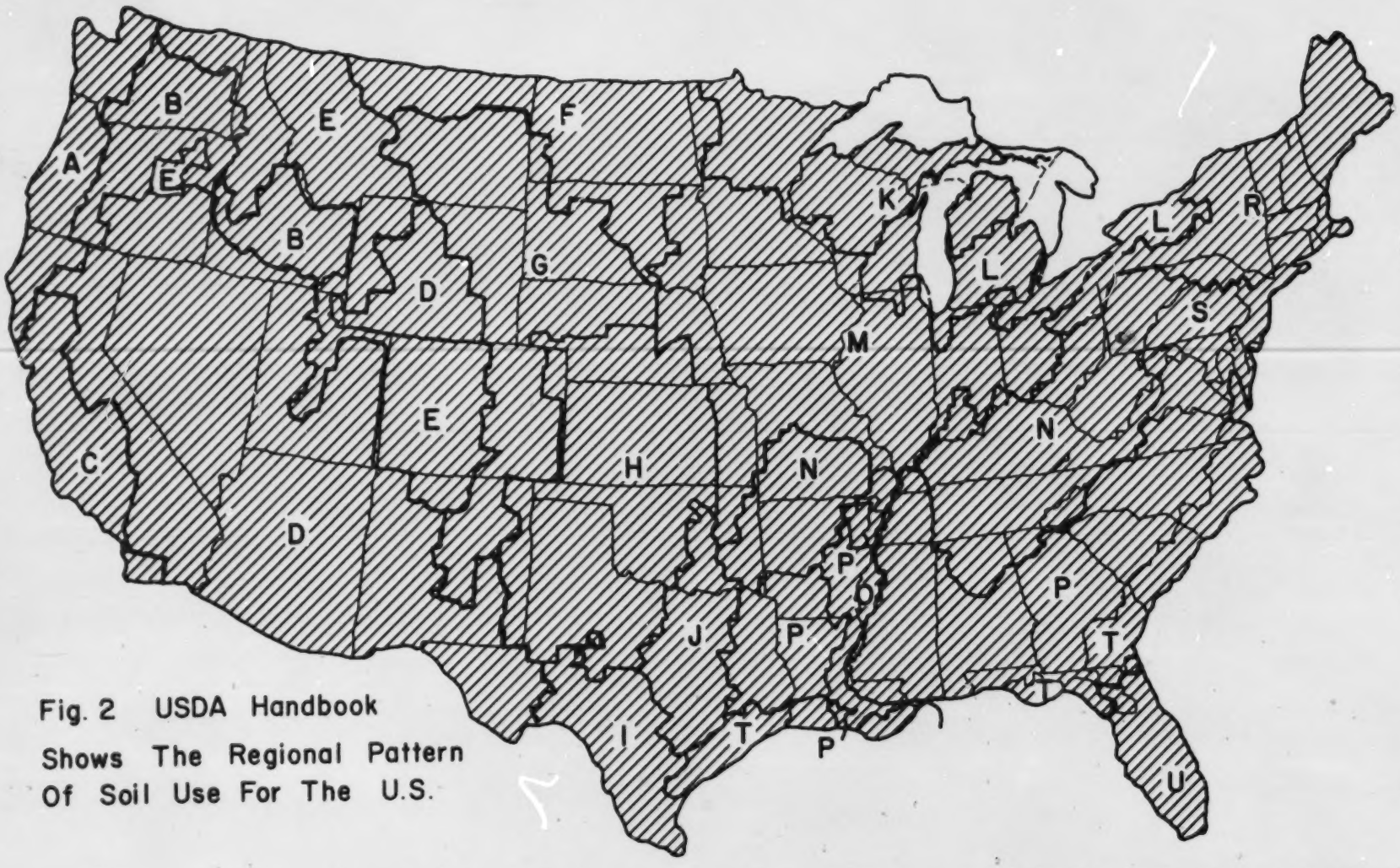


Fig. 2 USDA Handbook Shows The Regional Pattern Of Soil Use For The U.S.

The map on this page shows land resource regions (indicated by letter). These regions are defined mainly by similarity of soil patterns and climate but also by other natural features that affect use and management of land.

Descriptions of the 20 land resource regions and CNI data for the nonfederal rural land in each region are summarized on these pages. Detailed descriptions of these regions are contained in the U.S. Department of Agriculture's Agriculture Handbook 296, Land Resource Regions and Major Land Resource Areas of the United States, issued in December 1965. See next page for letter definitions.

A. Northwest coast region

Steep mountains; gently sloping valleys; plains. Inventory area, 58 percent of region. Suitable for regular cultivation (classes I-III), 17 percent. Dominant soil limitation: erosion hazard, 72 percent; shallowness, stoniness, droughtiness, 17 percent. Land use: commercial forest, 74 percent; cropland, 11 percent. Conservation treatment needed: 60 percent of commercial forest; 66 percent of cropland.

B. Columbian region

Mostly smooth to deeply dissected plains and plateaus; few mountain ranges. Inventory area, 61 percent of region. Suitable for regular cultivation, 33 percent. Dominant soil limitation: erosion hazard, 57 percent; shallowness, stoniness, droughtiness, salinity, 31 percent. Land use: cropland, 37 percent; range, 40 percent; commercial forest, 15 percent. Conservation treatment needed: 76 percent of cropland; 72 percent of range; 66 percent of commercial forest.

C. California coast region

Low mountains; broad valleys. Inventory area, 71 percent of region. Suitable for regular cultivation, 35 percent. Dominant soil limitation: erosion hazard, 47 percent; shallowness, stoniness, droughtiness, salinity, 35 percent. Land use: cropland, 30 percent; range, 26 percent; noncommercial forest, 29 percent. Conservation treatment needed: 71 percent of cropland; 54 percent of range.

D. Mountain and basin region

Plateaus, plains, basins; many isolated mountain ranges. Semidesert to desert. Inventory area, 41 percent of region. Suitable for regular cultivation, 7 percent. Dominant soil limitation: shallowness, stoniness, droughtiness, salinity, 54 percent; erosion hazard, 31 percent. Land use: range, 67 percent; noncommercial forest, 13 percent; cropland, 6 percent. Conservation treatment needed: 75 percent of range; 70 percent of cropland.

E. Rocky Mountain region

Rugged mountains; some broad valleys and high plateaus. Inventory area, 39 percent of region. Suitable for regular cultivation, 15 percent. Dominant soil limitation: erosion hazard, 56 percent; shallowness, stoniness, droughtiness, salinity, 33 percent. Land use: range, 43 percent; commercial forest, 25 percent; cropland, 16 percent. Conservation treatment needed: 62 percent of range; 70 percent of commercial forest; 67 percent of cropland.

F. Northern plains region

Mostly smooth topography. Inventory area, 91 percent of region. Suitable for regular cultivation, 72 percent. Dominant soil limitation: erosion hazard, 60 percent; adverse climate, 17 percent. Land use: cropland, 59 percent; range, 33 percent. Conservation treatment needed: 55 percent of cropland; 54 percent of range.

G. Western plains region

Mostly plains; sand hills and valleys; steep slopes. Inventory area, 88 percent of region. Suitable for regular cultivation, 20 percent. Dominant soil limitation: erosion hazard, 68 percent; shallowness, stoniness, droughtiness, salinity, 22 percent. Land use: range, 74 percent; cropland, 18 percent. Conservation treatment needed: 60 percent of range; 62 percent of cropland.

H. Central plains region

Plains; tableland; prairies. Inventory area, 100 percent of region. Suitable for regular cultivation, 53 percent. Dominant soil limitation: erosion hazard, 65 percent; shallowness, stoniness, droughtiness, salinity, 13 percent. Land use: cropland, 47 percent; range, 48 percent. Conservation treatment needed: 58 percent of cropland; 61 percent of range.

I. South Texas region

Plateaus and plains. Inventory area, 97 percent of region. Suitable for regular cultivation, 29 percent. Dominant soil limitation: shallowness, stoniness, droughtiness, salinity, 46 percent; erosion hazard, 37 percent. Land use: range, 76 percent; cropland, 10 percent. Conservation treatment needed: 76 percent of range, 64 percent of cropland.

J. Southern prairie region

Prairies and timbered areas; mostly gentle topography. Inventory area, 90 percent of region. Suitable for regular cultivation, 57 percent. Dominant soil limitation: erosion hazard, 63 percent; shallowness, stoniness, droughtiness, 24 percent. Land use: cropland, 27 percent; pasture, 26 percent; range, 24 percent. Conservation treatment needed: 64 percent of cropland; 77 percent of pasture; 81 percent of range.

Table 1. SCS Describes Each of 25 Regions Shown in Fig. 2.

K. Northern lake region

Level to gently rolling glacial drift, till, and lake plains; many swamps, lakes, and wet lowlands. Inventory area, 83 percent of region. Suitable for regular cultivation, 48 percent. Dominant soil limitation: wetness, 41 percent; erosion hazard, 31 percent; shallowness, stoniness, droughtiness, 27 percent. Land use: commercial forest, 65 percent; cropland, 19 percent. Conservation treatment needed: 52 percent of commercial forest; 54 percent of cropland.

L. Southern lake region

Nearly level to gently sloping glacial plains. Inventory area, 85 percent of region. Suitable for regular cultivation, 79 percent. Dominant soil limitation: wetness, 48 percent; erosion hazard, 34 percent. Land use: cropland, 63 percent; commercial forest, 22 percent. Conservation treatment needed: 58 percent of cropland; 65 percent of commercial forest.

M. North-central region

Nearly level to rolling plains; sharply dissected glacial till or drift plains. Inventory area, 95 percent of region. Suitable for regular cultivation, 78 percent. Dominant soil limitation: erosion hazard, 54 percent; wetness, 29 percent. Land use: cropland, 68 percent; pasture, 12 percent; commercial forest, 11 percent. Conservation treatment needed: 67 percent of cropland; 72 percent of pasture; 79 percent of commercial forest.

N. Appalachian-Ozark region

Mountains; valleys; dissected plateaus. Inventory area, 76 percent of region. Suitable for regular cultivation, 33 percent. Dominant soil limitation: erosion hazard, 58 percent; shallowness, stoniness, droughtiness, 31 percent. Land use: commercial forest, 59 percent; cropland, 19 percent; pasture, 16 percent. Conservation treatment needed: 74 percent of commercial forest; 66 percent of cropland; 71 percent of pasture.

O. Mississippi delta region

Flood plains; terraces. Inventory area, 68 percent of region. Suitable for regular cultivation, 79 percent. Dominant soil limitation: wetness, 79 percent; erosion hazard, 10 percent. Land use: cropland, 55 percent; commercial forest, 35 percent. Conservation treatment needed: 64 percent of cropland; 77 percent of commercial forest.

P. South Atlantic slope region

Coastal plains and Piedmont plateaus; some highly dissected areas. Inventory area, 100 percent of region. Suitable for regular cultivation, 54 percent. Dominant soil limitation: erosion hazard, 53 percent; wetness, 31 percent. Land use: commercial forest, 65 percent; cropland, 20 percent. Conservation treatment needed: 74 percent of commercial forest; 68 percent of cropland.

R. Northeastern region

Plateaus; plains; mountains. Inventory area, 87 percent of region. Suitable for regular cultivation, 33 percent. Dominant soil limitation: shallowness, stoniness, droughtiness, 55 percent; erosion hazard, 23 percent; excess water, 21 percent. Land use: commerical forest, 69 percent; cropland, 15 percent. Conservation treatment needed: 75 percent of commercial forest; 60 percent of cropland.

S. North Atlantic slope region

Undulating to rolling, dissected coastal plains; Piedmont plateaus; Appalachian ridges and valleys. Inventory area; 88 percent of region. Suitable for regular cultivation, 50 percent. Dominant soil limitation: erosion hazard, 56 percent; shallowness, stoniness, droughtiness, 24 percent; wetness, 17 percent. Land use: commercial forest, 54 percent; cropland, 28 percent. Conservation treatment needed: 56 percent of commercial forest; 64 percent of cropland.

T. Atlantic coast region

Nearly level lowlands. Inventory area, 83 percent of region. Suitable for regular cultivation, 57 percent. Dominant soil limitation: wetness, 75 percent; shallowness, stoniness, droughtiness, salinity, 17 percent. Land use: commercial forest, 52 percent; cropland, 22 percent. Conservation treatment needed: 76 percent of commercial forest; 72 percent of cropland.

U. Florida subtropical region

Nearly level to gently rolling coastal plain; many swamps and marshes. Inventory area, 82 percent of region. Suitable for regular cultivation, 30 percent. Dominant soil limitation: wetness, 87 percent; shallowness, stoniness, droughtiness, 13 percent. Land use: commercial forest, 47 percent; cropland, 13 percent; pasture, 11 percent; range, 11 percent. Conservation treatment needed: 81 percent of commercial forest; 63 percent of cropland.

asking the state Soil Conservation Service Office (through the local SCS office) for any of the following:

-- summary of Conservation Needs Inventory data for your state or any number of states (contains data for each county and state totals)

-- state publications based on inventory data and interpretative reports

-- published soil surveys of counties in any state

The state conservationist can also help the engineer obtain computer printouts of Inventory data or special tabulations of the data for a land resource region or area.

Of interest to planners of land treatment systems are percentage breakdowns of land having certain agricultural limitations such as erosion hazard, wetness, or shallowness of soil. A broad summary of this information is given in Table 1 for each of the 25 regions identified on the map in Figure 2. Figure 2 also refers to the USDA Agriculture Handbook 296, available from the SCS, for more detailed treatment of this subject.

Land Uses Indicate Available Sites

Knowledge of current land use in an area indicates how much land is potentially suitable and/or available for waste application. For example, agricultural land can often serve or at least be adapted for use in waste treatment. Abandoned farmland and forestland may also be suitable. A cursory review of land use maps can avoid consideration of areas with urban or industrial development, historical values, or unique environmental features. Occasionally, the possible site will be limited to land already owned by a municipality or industrial concern. In such cases, the uses of the land surrounding the site should be evaluated to determine if these uses are compatible with a waste application system. Projected land use plans, where they exist, may also eliminate certain areas from consideration.

A review of land uses in the area will limit the choice of available and suitable sites.

Topography Determines Surface Water Movement

The overall configuration of the landscape determines the pathway and rate of surface water movement and often the subsurface flow. As such, topography affects how well the site will handle water and the extent of contact between

Topography affects how well a site will handle water and the extent of contact between wastes and soil.

waste constituents and soil particles. Except on very permeable soils, steep slopes increase the possibility of rapid surface runoff. Unchecked runoff can short-circuit the renovation process and may erode the soil as well.

There are no uniform regulations relating slope and waste application. The so-called Ten-States Standards for the Great Lakes Upper Mississippi River Basin (GLUMRB) however, gives generally acceptable limits for sprinkler irrigation systems. This report can be obtained by writing to Health Education Service, P.O. Box 7283, Albany, NY 12224. These guidelines state that slopes on cultivated fields should be limited to 4%. Slopes on sodded fields should not exceed 8%. Slopes of forest are limited to 8% for year-round operation although seasonal operations may be acceptable on slopes up to 14%. With other application methods, slope constraints vary. Existing overland flow systems are generally operated on slopes between 2% and 6%. Here, the length of slope must also be considered. A length of 175 feet was found to be sufficient for food processing wastes at a facility in Paris, Texas. Three hundred feet is considered to be the maximum length over which uniform distribution of wastewater can be maintained.

The degree of slope that will limit waste application varies with the type of system.

Examination of topography should not be limited to the slope of potential sites. Local variations in surrounding topography are useful in determining drainage patterns and locating areas where water is discharged or accumulates. For example, if a site is nearly level and adjacent to sloping terrain, it will probably receive excess water via surface runoff and/or subsurface lateral flow from the higher ground. Such conditions might preclude additional inputs of wastewater. Delivery of waste from source to site will also require the evaluation of topography.

Topography must also be evaluated for design of pipelines conveying wastewater to the site.

Soils and Geology Affect Waste Application

Almost all soil properties affect or are affected by waste application. Practical considerations obviously limit investigation in the preliminary stages of decision-making. Here the task is one of evaluating those character-

istics which are most restrictive or which best reflect the potential performance of the system. Evaluation is complicated by the fact that no well established guidelines exist. This is especially true for the overland flow and rapid infiltration methods of wastewater application. Nevertheless, the following soil properties and site characteristics are suggested for initial consideration.

Evaluate those soil characteristics that will be most restrictive to operation of site.

Texture Influences Choice of System

Soil texture, as discussed in Module 3, "Soil as a Treatment Medium", refers to the size distribution of mineral particles, from fine clays to gravels and cobbles. Texture reflects major differences in pore size and permeability as well as the surface area available for interaction with waste constituents. Medium textured soils, ranging from sandy loams to silty clay loams, are generally suitable for effluent irrigation and sludge application. These loamy soils often exhibit the best combination of water handling capabilities and waste renovation potentials. Coarse textured soils such as sands and gravels can accept large quantities of water without runoff, but renovation capabilities are often low. Rapid infiltration systems may be considered where coarse textured subsoils are overlain by medium textured surface layers, thereby increasing the potential for renovation. Fine textured soils, unless well structured, are only suitable for overland flow systems.

Soil texture tends to dictate type of application system.

Effective Depth Influences Renovation Ability

The actual thickness of unconsolidated material above a permanent water table, bedrock, or some other restricting layer, constitutes the effective depth of soil useful in the renovation of applied wastes. The effective depth requirements vary for different wastes and waste application approaches. For rapid infiltration systems, at least 10 feet of permeable, unconsolidated material above a water table is generally recommended. With effluent irrigation or sludge application, a minimum of 4 to 5 feet is commonly suggested. Specific state guidelines are covered in Module 5 "Legal Aspects". Lesser depths may be acceptable with very low application rates or where

The thicker the unconsolidated layer of soil is, the greater the capacity for renovation of wastes in the soil.

subsurface lateral flow allows additional contact between soil and waste constituents. Overland flow systems require the least effective depth since much of the actual treatment occurs at or very near the surface. Nevertheless, a foot or more of unconsolidated material overlying an impermeable layer will increase the renovation possibilities for waste constituents such as phosphorus and metals, which depend largely on adsorption reactions with soil particles. Some depth is also required for adequate root development of vegetative cover.

Potential sites for solid or liquid waste application should not be subject to flooding by adjacent rivers and streams during any part of the year.

Drainage Helps Determine Suitability of Site

Drainage, as a condition of the soil, refers to the frequency and duration of periods when the soil is free of saturation. Drainage classes, shown below, have been defined by the Soil Survey Division of the Soil Conservation Service (Soil Survey Staff 1951).

Very poorly drained - water remains at or on the surface most of the year

Poorly drained - water remains at or near the surface much of the year

Somewhat poorly drained - soils are wet for significant portions of the year

Moderately well drained - soils are seasonally wet (e.g. high water table in spring)

Well drained - water readily removed from the soil either by subsurface flow or percolation; optimum condition for plant growth

Somewhat excessively drained - water is rapidly removed from the soil; characteristic of many uniform sands

Excessively drained - very rapid removal of water with little or no retention

Soils of the very poorly drained, poorly drained, and somewhat poorly drained classes are seldom suitable for any kind of waste application unless some form of artificial drainage is installed. Moderately well drained, well drained, and somewhat excessively drained soils are generally suitable for waste application, with the well drained soils

Soils appropriate for waste application should be neither poorly drained nor excessively drained. They should satisfy the criteria for well-drained soil.

offering the greatest potential for waste renovation. Excessively drained soils provide such rapid removal of water that they essentially preclude waste renovation.

Permeability Dictates Hydraulic Loading

Water entry into the soil surface and movement through the unconsolidated material depends on permeability. The downward permeability to water of the most restricting layer in the upper few feet of soil is of particular concern since this value will largely dictate permissible hydraulic loading. Permeability values in the range of 0.6 to 6.0 inches/hour, for the most restricting layer in the upper 4 to 5 feet of soil, offer the best conditions for effluent irrigation or sludge application. Values below 0.2 inches/hour will generally require artificial drainage or the overland flow approach. At the other end of the scale, with permeabilities greater than 6.0 inches/hour, rapid infiltration may be acceptable where adequate waste renovation can be demonstrated.

The rate of downward movement of water through the unconsolidated layer greatly determines hydraulic loading rates.

Available Water Capacity Relates to Throughput Rate and Plant Water Uptake

The available water capacity (AWC), as defined in Module 3 "Soil as a Treatment Medium", refers to the maximum amount of water that can be retained in the soil against the force of gravity and yet be available to plant roots. Available water capacity depends on the effects of textural and structural variability in the upper few feet of soil where most renovation occurs. AWC values greater than 6 inches are generally desirable within the upper four feet of soil. With lower values, the decreased retention time for wastes in the soil will reduce the opportunity for renovation.

Available Water Capacity of soil should be greater than 6 in/upper 4 ft. for most successful operations.

Nature of Consolidated Material is an Important Consideration

The kind and condition of bedrock is of major importance for high-rate wastewater application systems or where overlying soils are shallow. Fractured rock allows wastes to move rapidly to groundwater with little opportunity for renovation.

Unfractured bedrock at shallow depths will act like a layer of clay, with the potential of poor drainage, groundwater mounding, and/or subsurface lateral flow depending on topography. On the other hand, fractured or fissured rock may allow unrenovated wastewater to percolate rapidly to the water table. This condition is particularly serious with high-rate systems or where wastewater or sludge application augment a high natural precipitation. Limestone (carbonate) bedrock is of particular concern since sinkholes may exist. Even when sinkholes are not initially a problem, waste additions may initiate their formation or expand those already present. Sinkholes, like fractured rock, can accelerate the movement of unrenovated wastes to groundwater.

A good site has bedrock that is neither fractured nor lies at too shallow depths.

Summaries of Climatic Data are Available

Climatic data for most locations in the U.S. are available from various publications of the National Oceanic and Atmospheric Administration (NOAA).

Monthly summaries of climatic data provides useful information on several climatic variables including total precipitation, maximum and minimum temperatures, and relative humidity values for every weather station in a given area. Evaporation data are included where available.

Climatic data are available for most locations of the U.S. in monthly summaries and 10-year summaries.

In the climatic summary of the U.S., climatic data for each weather station in a given area are summarized for a 10-year period. Specific information includes:

(a) total monthly precipitation for the 10-year period
(b) total monthly snowfall for the period
(c) average number of days per month when precipitation exceeds 0.10 and 0.50 inches
(d) average monthly temperatures for the period
(e) average daily maximum and minimum temperatures for the 10-year period
(f) average number of freezing days per month for the period.

Local climatological data provides an annual summary of climatic data for only a few major weather stations.

Storage Requirement Computer Programs were recently developed at the National Climatic Center in Asheville, NC (Whiting, 1975). Three versions are now available which utilize daily climatic data from over a period of years to identify the number of favorable and unfavorable days for waste application. From this analysis, storage requirements can be calculated. Module 8 "Climate and Wastewater Storage" provides detailed information on this source of design data.

Computer programs are available which identify favorable and unfavorable days for waste application in both cold climates and wet climates.

Planning Agencies Provide Land Use Information

Planning agencies at local, state, and/or regional levels can usually supply pertinent information on land use. Both current and projected land use patterns are helpful in evaluating the area. Available information, however, varies widely in terms of specificity.

Planning agencies at local, regional, and state levels have information on land use.

One example of a very detailed informational source is the New York State Land Use and Natural Resource (LUNR) Inventory which includes statewide land use data derived from the interpretation of recent aerial photographs. Relatively few states have developed such a detailed analysis for existing land use. The LUNR Inventory provides information on 130 categories of land use for all areas of the state. Data are available in three forms:

- -transparent map overlays for use with 7.5 minute USGS topographic maps or New York State Department of Transportation planimetric maps;
- -computer-tabular forms;
- -computer-graphic forms.

The computerized format allows for the addition of supplemental information. For example, the computerized portion of the LUNR Inventory currently includes a map of New York's geology, a generalized state soil map, and a map of economic viability of farm areas in the state. Further information on LUNR maps and data are available from:

New York State Office of Planning Services
Data and Systems Bureau
488 Broadway
Albany, New York 12207

Topographic Maps Serve Many Uses

The United States Geological Survey (USGS) publishes topographic maps for many areas in 7.5 and/or 15 minute series. These maps are usually at scales of 1:62,500 or 1:24,000. (A guide to the interpretation of map scales is given in Appendix A). Standard topographic maps are useful in describing the location of potential sites and in determining topographic variations, distance from waste sources, proximity to surface waters and to population centers, and in some cases current land-use and groundwater discharge areas.

Topographic maps help to locate available sites. Maps are available from U.S. Geological Survey.

Indexes to published maps are available for each state. These indexes and individual topographic maps may be obtained from:

Branch of Distribution
U.S. Geological Survey
1200 South Eads Street
Arlington, Virginia 22202

for Eastern States (east of the Mississippi)

Branch of Distribution
U.S. Geological Survey
Federal Center
Denver, Colorado 80225

for Central and Western States (west of the Mississippi)

Hydrogeologic Studies Report Water Levels, Quality

The Geological Survey also maintains a network of observation wells to monitor water levels and water quality. The observation well network consists of nearly 16,000 privately and publicly owned wells. Records of water level in about 3,500 of these observation wells are published in the USGS Water-Supply Paper series, "Groundwater Levels in the United States (name of geographic region)". This data will be useful in establishing the general groundwater quality of a region.

Information on groundwater levels and quality are available from U.S. Geological Survey.

The Geological Survey undertakes project investigations for area groundwater studies, generally in cooperation with local, state, or other federal agencies. These studies include: reconnaissance studies which describe the general geological features, the principal wells, springs, and aquifers, and appraise water quality; generalized studies which involve surface and subsurface geologic mapping, test drilling, geophysical work, systematic well inventories, programs for water level measurement, mapping of water level contours, depth to water, saturated thickness,

Extensive information on local groundwater conditions is available from state geological survey offices.

transmissibility, storage capacity, and water quality zones; intensive studies which are detailed investigations of lithology, porosity, horizontal and vertical permeability, transmissibility, storage coefficients, and water quality as well as all types of mapping performed in the generalized studies. Results of these studies are published either by the USGS in its various publication series or in state reports in cooperation with local agencies. Further information on these sources can be obtained from the previous addresses, from State Geological Survey Offices, or State Divisions of Water Resources. An example of the use of such information in delineating waste application areas is provided by Bond, et al. (1972).

Soil Surveys Provide Wealth of Information

Soil surveys have been made and published since 1899 by various government agencies. In 1952, all survey activity was consolidated in the Soil Conservation Service and designated the National Cooperative Soil Survey. Soil Survey Reports include maps, showing the distribution of different soils and interpretations for the use of these soils. Most reports issued prior to about 1960 include interpretive information limited to farming operations. The more recent reports, however, provide ratings and interpretations for many other uses including engineering applications, wildlife, recreation and community planning. As such, Soil Survey Reports constitute a valuable source of information in planning and designing land treatment systems. Specific kinds of information are discussed in the following sections.

Soil Surveys since 1960 rate soils on their suitability for various uses as well as examine the basic soil properties.

Soil Maps Cover Entire County or More

Modern soil survey reports contain a general soil map covering an entire county or more, and several detailed soil maps covering individual portions of the larger area. Detailed maps are published on an air photo base. The soil delineations shown on either type of map are called mapping units. General maps show soil associations and are generally published at a scale of 1:126,720 (0.5 inches to the mile) or smaller. Detailed maps which delineate types of phases

Dominant soil types are delineated on soil maps.

of soil series, soil complexes, and undifferentiated units, are usually published at a scale of 1:15,840 (4 inches to the mile) or 1:20,000 (3.17 inches to the mile). In order to use soil survey reports effectively, it is necessary to understand the various mapping units employed and the limitations involved.

A soil association is a group of geographically associated soil units occurring in a defined proportional pattern over the landscape. Associations are named for the dominant soil or soils present, such as Madrid-Massena or Ontario-Hilton. The basis for grouping soils into associations, however, varies with the purpose and scale of the map. The colored map provided on the back cover of the attached Monroe County Soil Survey is an example of a general soil map.

General Maps Are Limited

A map showing only soil associations is used to get a general idea of the soils in a county or to locate large tracts which are suitable for a certain land use such as waste application.

An association map, however, is limited in that the different soils in any association ordinarily differ greatly in slope, depth, stoniness, drainage, and other characteristics that strongly affect their management. In addition, information reflects soil conditions only to a depth of 4 to 5 feet.

Detailed Maps Indicate Soil Types

Groups of soils with similar profile characteristics are designated as a soil series. Each series is named for a town or other geographic feature located near the place where a soil of that series was first observed and mapped. Examples are the Cayuga Soil Series named for Cayuga Lake, New York, and the Ovid Soil Series named for Ovid, New York.

More detailed maps are needed to determine individual soil types which differ in their surface texture.

Soil series maps include soils which differ in the texture of their surface layer. Within a series, all soils having a surface layer of the same texture belong to one soil type, such as Hilton loam. Soil types may vary in slope, degree of erosion, or some other feature which affects

their use. Therefore, soil types are further divided into soil phases which form a basic mapping unit on detailed soil maps. An example is Cayuga silt loam, 0 to 2 % slopes. When different soils are so intricately mixed or occur in individual tracts too small to show them separately on the maps, they are shown as one mapping unit called a soil complex. The soils in a complex may be similar or sharply contrasting. A complex is ordinarily named for the major soils within it. An example is Hilton-Cazenovia stony silt loams, 0 to 3% slopes. Some delineations shown on detailed maps are undifferentiated units. These consist of two or more soil types or phases that have been grouped together because of similarities of properties and management needs. The pattern and proportion of the included soils are not uniform. Undifferentiated units are named for dominant soils joined by "and" (as opposed to soil complexes where names are joined by a hyphen). An example is Ovid and Appleton silt loams, limestone substratum. Before going on, take a moment to study the detailed maps provided in the accompanying Monroe County Soil Survey.

Soil phases describe the slope and degree of erosion as well as the texture of individual soils.

Detailed Maps Have Limitations

Detailed soil maps offer a greater amount of information than general maps since the mapping units are more refined. Nevertheless, individual named units, as designated on detailed maps, always contain variable amounts of different soils due to limitations of the mapping scale. For purposes of management interpretations such inclusions of unidentified soils seldom exceed 15% of the area designated by a particular mapping unit. This means that approximately 85% or more of an area shown on the map as Ontario loam, will in fact consist of Ontario loam or other soil units which respond similarly to management. The remaining 15%, however, may consist of quite different soils in terms of management interpretations. For example, Figure 3 shows an area mapped at the customary 1:20,000 scale and at a much larger scale of approximately 1:2,750. At the normal scale for published detailed maps, this area was named as a complex,

Detailed maps do not precisely describe each soil type at the site. Rather they describe the major soil types comprising at least 85% of the area.

Valois-Howard gravelly loams, 8% to 15% slopes. On the small scale map, however, it can be seen that the area actually consists of the two major soils as well as five minor soils.

The major soils, designated by the symbols VaC and HdC, are well drained; the minor soil inclusions range from moderately well drained to very poorly drained. The minor areas were not indicated on the detailed soil map as published, but could markedly affect the performance of a site used for waste application. For this reason, there is the need for an on-site visit by an experienced soil scientist before any final design decisions are made. Detailed soil maps, like general maps, are also limited by the depth of the soil conditions they reflect, which is a maximum of about 4 to 5 feet.

Because minor soil types at the site may affect its operation, an experienced soil scientist should be consulted before final design decisions are made.

Soil Surveys Describe Soils

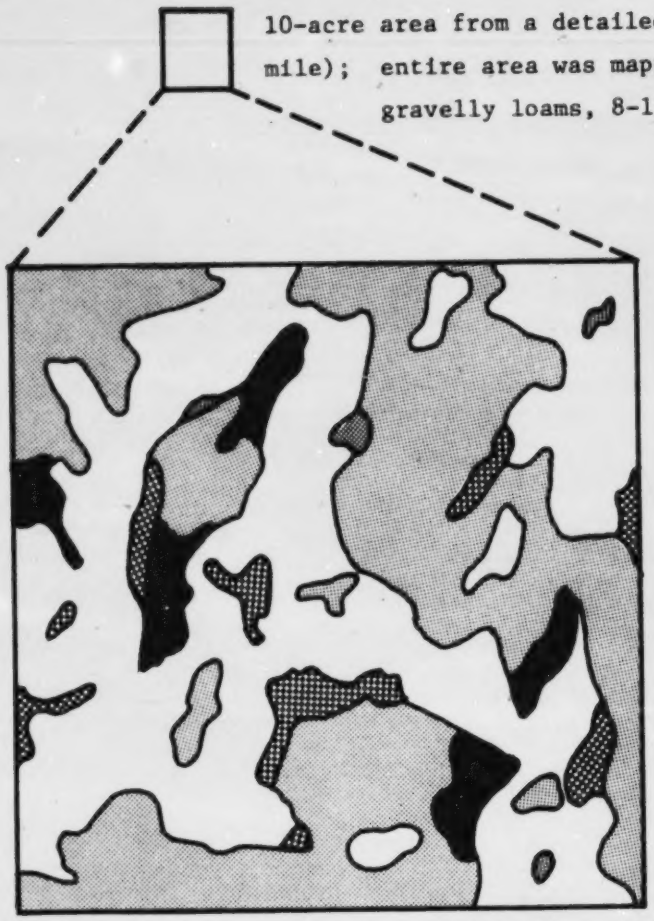
Description of mapping units for both general and detailed maps are provided in the text of the soil survey report. The approximate acreage and proportional extent of each unit is given. Each series description has a short narrative describing a representative profile, and a much more detailed description of the same profile from which highly technical interpretations can be made. Examples of these descriptions appear on pages 105-161 of the Monroe County Soil Survey.

Soil Survey Indicates Land Use, Management

In addition to maps and descriptions of soils, soil survey reports contain considerable information on the use and management of soils. In the most recent reports, such information includes:

Recent soil surveys give extensive information on how land is farmed and the potential of the land for other uses.

1. general management of soils for farming
2. capability groupings of soils according to suitability
3. estimates of yields for various crops on different soils
4. groupings of soils for use as woodland
5. groupings of soils for use as wildlife habitat
6. interpretations and ratings for engineering applications
7. interpretations and ratings for non-farm (urban) areas



10-acre area from a detailed soil map (1:20,000 or 3.17 inches per mile); entire area was mapped as a soil complex -- Valois-Howard gravelly loams, 8-15% slopes

same 10-acre area mapped at much smaller scale (1:2,743 or 23.1 inches per mile), showing more intricate pattern involving two major soils and five minor soils

VaC Valois gravelly loam, 8-15% slopes (well drained soil on poorly sorted gravelly material

HaC Howard gravelly loam, 8-15% slopes (well drained soil on well sorted gravel)

AmA Alden and Birdsall silt loams, 0-3% slopes (very poorly drained spots)

Ellery channery silt loams, 0-8% slopes (somewhat poorly drained to poorly drained spots

Langford channery silt loam, 3-8% slopes (moderately well drained spots)

FIGURE 3. At the normal scale for detailed soil maps, there is a limit to the amount of soil variability that can be shown. Therefore, areas designated by a particular mapping unit will almost always contain inclusions of unidentified soils. These inclusions may be in sharp contrast to the characteristics of the named soil(s). (adapted from Olson 1964)

Use of Soil Surveys Illustrated

To illustrate the use of a soil survey for land application site evaluation, we will examine the information that can be obtained for a hypothetical land treatment investigation at Penfield, New York. Maps of the Penfield area are from the Soil Survey of Monroe County, which accompanies this module. Using these maps, charts of engineering and agricultural properties in the reports, and the advice of soil specialists, the consulting engineer can make judgements about the site's ability to absorb the volume of water to be applied; the potential groundwater movement problem; constraints in the use of the soil for irrigation, drainage, and ponds; and depth of the soil to bedrock.

An examination of potential waste treatment sites in Penfield, New York, illustrates how to use a soil survey.

Soil surveys also give available water capacity and expected yields for various crops--useful in evaluating treatment alternatives. Land use is shown on the aerial photos in the soil mapping.

For the Penfield example, a site consisting of five blocks of land divided by roads or natural physical boundaries has been marked on the soil map (Figure 4 on page 22) Information is obtained from the tables in the Survey which accompanies this module.

Acreages for each plot are shown. Total area = 1460 acres.

For the purpose of illustration, one block will be examined:

1) Block D: Predominant soil type Madrid (Md)

--Permeability: 2.0 in./hr. at all depths

--Irrigation use: High intake rate
Moderate to high available water capacity

--Agricultural drainage: Drainage not needed
Naturally well drained

--Depth to bedrock: 6 ft.

--Seasonal highwater table: 4 ft. deep

Based on these factors, this section of Penfield would not be suitable for land treatment by rapid infiltration due to its depth to bedrock and depth to

high water table, although permeability values are acceptable. It would be well suited to crop irrigation due to its high available water capacity in addition to the other factors listed above.

The other soils in the block are now examined for potential constraints:

--Massena (Mf) has high seasonal water table of 0.5 to 1.5 ft. depth. Can be poorly drained. Could be some influence on groundwater movement, but depth to bedrock is more than 6 ft. Not a large area of Mf.

--Ontario (On) has slightly higher seasonal water table (2.5 to 4 ft.) and lower permeability range (0.63 to 2.0 in./hr. in topsoil and less than 0.63 in./hr. below 39 in. deep). No restrictions.

--Sun (Ss) has prolonged high water table (0 to 0.5 ft. depth) and widely varying permeability (0.63 to 6.3 in./hr.) and would affect groundwater movement.

From this information, the engineer can draw these conclusions:

--The site has the Sun soil as a limiting factor. Because of the prolonged high water table, wastewater probably should not be applied directly to this portion of the site.

--There is no high bedrock to impede groundwater movement laterally from the site.

--The predominant soil has excellent wastewater-accepting characteristics.

A similar analysis would be carried out for each of the other blocks of land (A, B, C, and E) shown in Figure 4.

Information Designed to Aid Farmers

Much of the information provided in soil surveys is designed to help farmers, or those who advise farmers, in choosing suitable combinations of soil, water, and crop management practices. Individual soil characteristics that affect general management in the county are discussed; often included are acidity (pH), the effect of subsoil properties on root growth, nitrogen, phosphorus, and potassium relationships in area soils, and crop adaptation details.

Much information in Soil Surveys is devoted to how suitable the land is for growing field crops.

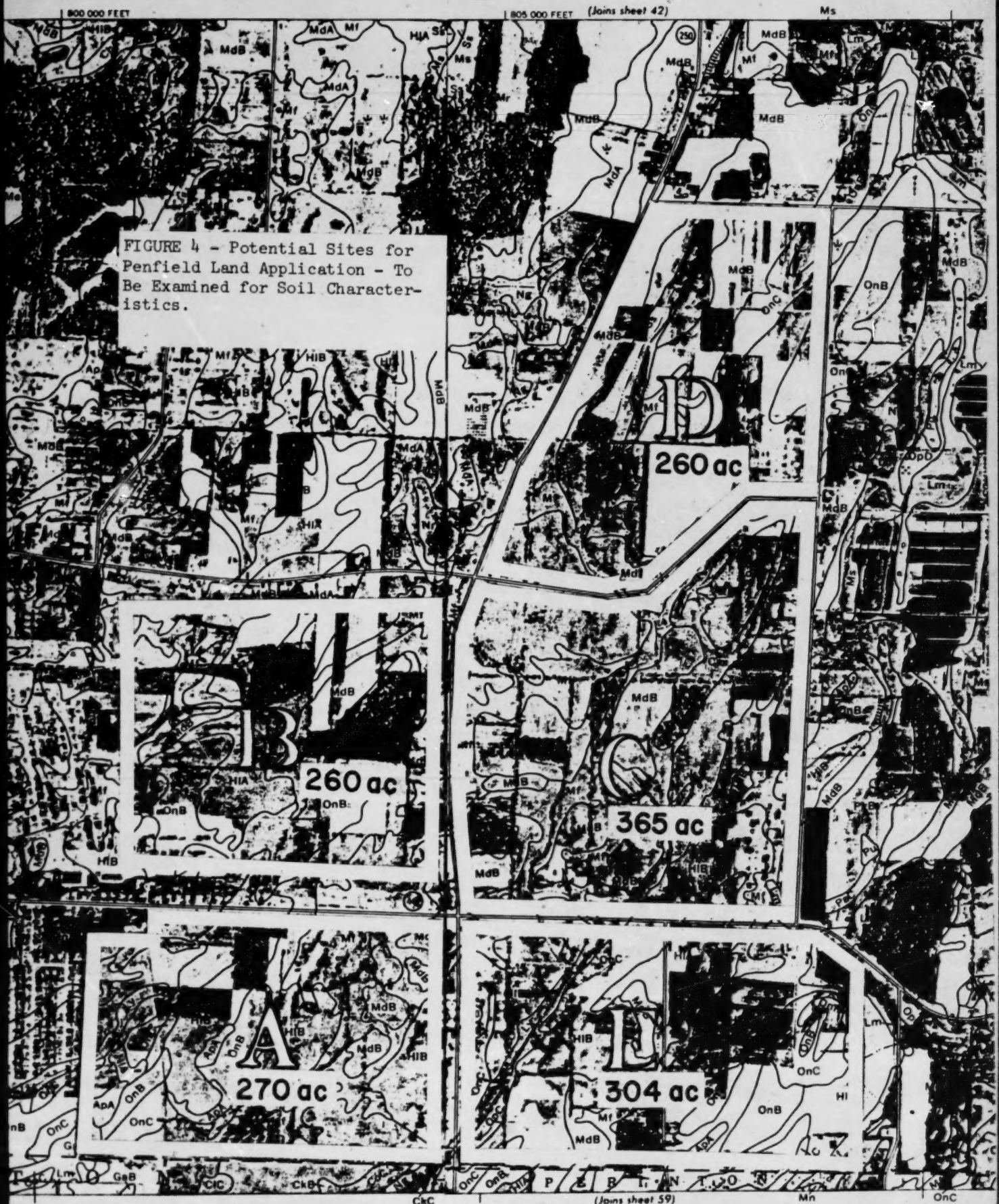


FIGURE 4 - Potential Sites for Penfield Land Application - To Be Examined for Soil Characteristics.

Describes Suitability of Soils for Crops

Capability groupings indicate the general suitability of soils in the area for most kinds of field crops. These groupings do not take into account major earthmoving that would have changed the slope, depth, or other characteristics of the soil in place.

Soils are grouped at three levels: the capability class, subclass, and unit. Eight classes indicate the degree of limitation of a particular soil; they range from Class I, including soils which have few limitations to restrict their use, to Class VIII, for soils which have such severe limitations so as to preclude their use for any kind of cropping. Subclasses designate the type of limitation; the small letter e indicates erosion, w is for wetness, s denotes shallowness, and c indicates climatic limitations. Capability units, designated by arabic numerals represent further delineations within subclasses. Soils in the same unit are enough alike to require similar management and show similar responses to management. Examples of capability groupings appear on pages 10-21 of the Monroe County Soil Survey.

Soils are classified according to how limitations restrict their use for crops; specific limitations are noted.

Estimated average yields are given for principal crops on each soil in the area which is suitable for cultivation. Yield estimates are generally provided for two levels of management:

--yields obtained by farmers for a period of years preceding the published survey report

--yields which can be expected under highly skilled or improved management schemes.

Examples of this information appear on pages 21-30 of the Monroe County Soil Survey.

Estimates for average crop yields are given including yields actually obtained and yields expected under improved management.

Soils Rated for Woodland and Wildlife Suitability

Area soils are rated in terms of their suitability to support various tree species. The number of suitability groups and their specific meanings are not standardized and thus vary with the county or area involved. Woodland suitability ratings appear on pages 30-34 of the Monroe County Soil Survey.

Soils are rated according to their ability to support certain tree species and wildlife.

Soils are rated according to various elements of wildlife habitat including plant cover and/or open water, and also in terms of different classes of wildlife such as openland wildlife, woodland wildlife, and wetland wildlife. An example of these ratings appears on pages 34-42 of the Monroe County Report.

Recent Reports Contain Engineering Applications

Specific information on the engineering uses of soils is generally absent from soil survey reports published prior to about 1960. In more recent reports, however, considerable data and interpretative information are provided. Soils are classified according to three systems: the U.S. Department of Agriculture system (USDA) based on the texture of the mineral soil particles, the American Association of State Highway Officials system (AASHO) based on load-carrying capacities, and the Unified System, used by the Corps of Engineers, based on textural and plasticity qualities. Engineering test data are given for selected soils. Various parameters are defined and discussed in the text, and tabulated in the soil survey.

Recent Soil Surveys give engineering classifications of soils according to USDA, AASHO, and Unified systems.

Estimated soil properties are given for each detailed mapping unit, including:

depth to bedrock
depth to seasonal high water table
dominant textural changes with depth
permeability (inches/hour)
available water capacity
reaction (pH)

Also, engineering interpretations for each detailed mapping unit, including:

as:

suitability as a source of topsoil
granular material (sand, gravel)
fill material

Soil features affecting
embankment foundations
foundations for low buildings
ponds
agricultural drainage
irrigation
diversions
waterways

Examples of these types of information are given on pages 42-81 of the Monroe County Soil Survey.

A discussion in the text of the report is also provided on the engineering properties of geologic deposits and bedrock.

Recent Reports Describe Non-Farm Uses

Interpretive information on non-farm uses is generally limited to only the most recent soil survey reports. In such cases, soil ratings are provided for: sanitary landfills
disposal of septic tank effluent
homesites
streets and parking lots
recreational areas (picnic grounds, athletic field, hiking and riding trails, lawns and fairways, campsites)

Recent Soil Surveys rate how well land is suited for sanitary landfills, recreation, homesites, and other non-farm uses.

Examples appear on pages 82-104 of the Monroe County Report.

Some soil survey reports also provide data on selected chemical properties of soils such as cation exchange capacity. When available, such data are often limited to only a few soil series. Additional information is given on general features of the county or area such as population, major industrial or manufacturing facilities, climate, geology, gross relief, drainage and physiography, and water supply.

Soil Surveys describe general features of the area such as water supply, drainage, major industries.

By now it should be apparent that soil survey reports, particularly the most recent ones, can provide an enormous amount of pertinent information for feasibility evaluations and designs of land treatment systems. Note, however, that this information does not preclude the need for on-site inspections nor small-scale pilot runs to verify the predicted performance of specific wastes in the soil.

A nationwide listing of published soil survey reports along with information on how to obtain them is given in Appendix B. If only older reports or no reports are published for an area, unpublished materials are often available from county Soil Conservation Service personnel. Furthermore, soil series names are more or less standardized all over the country. Therefore, a soil of the Ovid series may occur in several counties or even several states. When no recent survey is available for the area of interest, older reports may be augmented with recent materials from adjacent counties.

If only older Surveys are available, they should be augmented by recent Surveys from nearby regions, unpublished SCS materials, or consultation with SCS personnel.

Aerial Photos Serve as Additional or Alternative Resource

The amount of information obtainable from aerial photos is directly related to the experience of the personnel using them. Nevertheless, those without experience can still obtain useful information.

For evaluating waste application areas, air photos may be of greatest use when other sources such as soil survey reports or topographic maps are not available. Land use patterns are easily recognized from air photos. Tonal differences and photographic textural changes can serve to delineate forestlands, grasses, various cultivated crops, and bare soil. The value of this information will depend on how recently the photographs were made, and the date (time of year) they were taken. In addition, subtle drainage differences that might be quite difficult to detect on the ground often can be detected on air photos. Other features of the landscape such as old river channels or intermittent drainageways may also be discerned. In general, however, air photos are best used to complement rather than replace other information sources and serve to reduce field

Aerial photos are of greatest use when other information sources are not available.

Land use, drainage, topography can be detected in aerial photos.

work rather than take its place.

Air photos commonly occur as oblique photographs, vertical photographs, and/or composite photographs. Oblique photos are taken with the axis of the camera at various angles between the horizon and the ground. They usually cover a larger area than verticals but their usefulness is limited to fairly level terrain where the view is not obstructed by ridges or highlands. Vertical photographs are taken with the aerial camera pointed straight down. Overlapping exposures in each flight line permit the interpreter to study vertical photos three-dimensionally, using a stereoscope. Unless otherwise specified, aerial photos are understood to be verticals. Mosaics are composite pictures assembled from individual vertical photos, matched to give the appearance of a single large print. Such mosaics form the base on which detailed soil maps are published. Aerial photographs range in scale from about 1:12,000 to 1:20,000. A scale of 1:20,000 is about the smallest that nonprofessional interpreters can use efficiently. Enlargements can be made, but in general they offer no additional detail and cannot be viewed with simple stereoscopes. Enlargements, however, may present definite advantages in the transfer of photo details to base maps.

Aerial photos of most of the United States, by counties, can be obtained from the Geological Survey.

Most of the United States has been photographed in recent years for various federal agencies. A key to this photography is available in map form as the "Status of Aerial Photography in the U.S.". Copies may be obtained from:

Map Information Office
U.S. Department of the Interior
Geological Survey
Washington, D.C. 20240

This map shows all areas of the U.S., by counties, that have been photographed by or for the Agricultural Stabilization and Conservation Service, Soil Conservation Service, Forest Service, Geological Survey, Corps of Engineers, Air Force, Coast and Geodetic Survey, and commercial firms. Names and addresses of agencies holding the negatives for the

photographs are printed on the back of the map, and inquiries should be sent directly to the appropriate organization. There is no central laboratory that can furnish all prints of all government photography. Photo index sheets or index mosaics showing the relative positions of all individual photographs within a given county can usually be examined at local offices of the Agricultural Stabilization and Conservation Service or the Soil Conservation Service.

In summary, there is a variety of information available to help the operator and designer of the land application system. Persons involved in land treatment should be aware of the sources in order to use this information to their advantage.

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APPENDIX

Information on Obtaining Soil Survey Reports

and

List of Published Soil Surveys

Appendix

Information on Obtaining Soil Survey Reports
and
List of Published Soil Surveys
USDA, Soil Conservation Service - January, 1976 and updates as of May, 1977

A soil survey published by the U. S. Department of Agriculture that is not out of print can be obtained in one of the following ways:

Land users in the area surveyed and professional workers who have use for the survey can obtain a free copy from the local office of the Soil Conservation Service, from their county agent, or from their congressman. Many libraries keep published soil surveys on file for reference. Also, soil conservation district officers and county agricultural extension offices have copies of local soil surveys that can be used for reference.

Most published soil surveys cover one or more counties and are so named. Where the survey covers only a part of one or more counties, the word "area" is a part of the name. The date in the list that follows is the year the field work was completed for surveys made from 1899 to 1936; from 1937 on, it is the year the publication was issued.

Soil surveys are being completed and published at a rapid rate, so this list is always somewhat out of date. For information on the current status of a soil survey not listed herein, inquiry should be made at the Soil Conservation Service field office in that county or at the office of the Director of Soil Survey Operations, Soil Conservation Service U.S. Department of Agriculture, Washington, D. C. 20250. In some cases it is possible to obtain drafts of forthcoming surveys, if they are sufficiently close to completion.

PUBLISHED SOIL SURVEYS

January 1976

ALABAMA

*1908 AUTAUGA
*1909 BALDWIN
1964 BALDWIN
*1914 BARBOUR
*1908 BIBB
*1905 BLOUNT
*1913 BULLOCK
*1907 BUTLER
*1908 CALHOUN
1961 CALHOUN
*1909 CHAMBERS
1959 CHAMBERS
1924 CHEROKEE
*1911 CHILTON
1972 CHILTON
1921 CHOCTAW
*1912 CLARKE
*1915 CLAY
1974 CLAY
*1913 CLEBURNE
*1909 COFFEE
*1908 COLBERT
1939 COLBERT
*1912 CONECUH
*1929 COOSA
*1912 COVINGTON
1921 CRENSHAW
*1908 CULLMAN
1962 CULLMAN
*1910 DALE
1960 DALE
*1905 DALLAS
1938 DALLAS
1958 DEKALB
*1911 ELMORE
1955 ELMORE
*1913 ESCAMBIA
1975 ESCAMBIA
*1908 ETOWAH
*1917 FAYETTE
1965 FAYETTE
*1903 FORT PAYNE AREA
1927 FRANKLIN
1965 FRANKLIN
1920 GENEVA
*1923 GREENE
1971 GREENE
*1909 HALE
1939 HALE
*1908 HENRY
*1920 HOUSTON
1968 HOUSTON
*1903 HUNTSVILLE AREA
*1911 JACKSON
1954 JACKSON
*1908 JEFFERSON
*1908 LAMAR
*1905 LAUDERDALE
1931 LAUDERDALE
*1914 LAWRENCE
1959 LAWRENCE
*1906 LEE
1950 LEE
*1914 LIMESTONE
1953 LIMESTONE
*1916 LOWNDES
*1904 MACON
1944 MACON
*1911 MADISON
1958 MADISON
*1920 MARENGO
*1907 MARION
*1911 MARSHALL
1959 MARSHALL
*1911 MOBILE
1930 MOBILE
*1903 MOBILE AREA
*1916 MONROE
*1905 MONTGOMERY
*1926 MONTGOMERY
1960 MONTGOMERY
*1918 MORGAN
1944 MORGAN
*1902 PERRY
1930 PERRY
*1917 PICKENS
*1910 PIKE
*1911 RANDOLPH
1967 RANDOLPH
*1913 RUSSELL
*1917 SAINT CLAIR
*1917 SHELBY
*1904 SUMTER
1941 SUMTER
*1907 TALLADEGA
1974 TALLADEGA
*1909 TALLAPOOSA
*1911 TUSCALOOSA
*1915 WALKER
*1915 WASHINGTON
*1916 WILCOX
1938 WILCOX
1937 WINSTON

ALASKA

*1914 ALASKAN RECONNAISSANCE
1963 FAIRBANKS AREA
1971 HOMER-NINILCHIK AREA
*1916 KENAI PENISULA
1962 KENAI-KASILOF AREA
1968 MATANUSKA VALLEY AREA
1960 NORTHEASTERN KODIAK ISLAND AREA
1973 SALCHA-BIG DELTA AREA
1973 SUSITNA VALLEY

ARIZONA

1975 APACHE (CENTRAL PART)
1967 BEAVER CREEK AREA
*1921 BENSON AREA
*1927 BUCKEYE-BEARDSLEY AREA
*1941 CASA GRANDE AREA
1974 EAST MARICOPA AND NORTHERN PINAL
*1928 GILA BEND AREA
1964 HOLBROOK SHOW-LOW AREA
1974 LONG VALLEY AREA
*1917 MIDDLE GILA VALLEY AREA
*1930 NOGALES AREA
1973 ORGAN PIPE CACTUS NATIONAL MONUMENT
*1928 PARADISE-VERDE AREA
1970 SAFFORD AREA
*1900 SALT RIVER VALLEY AREA
*1926 SALT RIVER VALLEY AREA
*1921 SAN SIMON AREA
*1903 SOLMONSVILLE AREA
*1954 SULPHUR SPRINGS VALLEY AREA
1950 THE DUNCAN AREA
*1931 TUCSON AREA
1972 TUCSON-AVRA VALLEY AREA
1938 UPPER GILA VALLEY AREA
*1942 VIRGIN RIVER VALLEY AREA
*1921 WINSLOW AREA
*1902 YUMA AREA
*1904 YUMA AREA
1941 YUMA DESERT AREA
*1929 YUMA WELTON AREA

ARKANSAS

1972 ARKANSAS
*1913 ASHLEY
*1925 BRADLEY
1961 BRADLEY
1967 CHICOT
1968 CLEVELAND
*1914 COLUMBIA
*1907 CONWAY
*1916 CRAIGHEAD
1974 CRITTENDEN
1968 CROSS
1972 DESHA
*1917 DREW
*1917 FAULKNER
*1906 FAYETTEVILLE AREA
1971 FRANKLIN
1969 GREENE
*1916 HEMPSTEAD
*1917 HOWARD
1975 HOWARD
1974 JACKSON
*1915 JEFFERSON
*1921 LONOKE
*1903 MILLER
*1914 MISSISSIPPI
1971 MISSISSIPPI
*1925 NEVADA
1973 OUACHITA
*1920 PERRY
1974 PHILLIPS
*1913 POPE
*1906 PRAIRIE
*1922 PULASKI
1975 PULASKI
*1911 RECONNAISSANCE OZARK REGION
1975 SEBASTIAN
1966 ST. FRANCIS
*1902 STUTTGART AREA
1969 WASHINGTON
1968 WOODRUFF
*1915 YELL

* OUT OF PRINT ; NOT AVAILABLE FOR DISTRIBUTION

CALIFORNIA

1966 ALAMEDA AREA
*1931 ALTURAS AREA
*1965 AMADOR AREA
*1916 ANAHEIM AREA
1969 ANTELOPE VALLEY AREA
*1924 AUBURN AREA
*1904 BAKERSFIELD AREA
*1945 BAKERSFIELD AREA
*1937 BARSTOW AREA
*1920 BIG VALLEY AREA
1924 BISHOP AREA
*1920 BRAWLEY AREA
*1907 BUTTE VALLEY AREA
*1929 CAPISTRANO AREA
1971 CARSON VALLEY AREA
*1917 CENTRAL SOUTHERN AREA
*1925 CHICO AREA
*1927 CLEAR LAKE AREA
*1923 COACHELLA VALLEY AREA
*1952 COALINGA AREA
*1907 COLUSA AREA
*1939 CONTRA COSTA
*1931 DIXON AREA
1971 EASTERN FRESNO AREA
1974 EASTERN SANTA CLARA AREA
1964 EASTERN STANISLAUS AREA
*1930 EL CAJON AREA
*1918 EL CENTRO AREA
1974 EL DORADO AREA
*1921 EUREKA AREA
*1900 FRESNO AREA
*1912 FRESNO AREA
*1923 GILROY AREA
1968 GLENN
*1918 GRASS VALLEY AREA
*1901 HANFORD AREA
*1915 HEALDSBURY AREA
*1923 HOLLISTER AREA
*1915 HONEY LAKE AREA
*1901 IMPERIAL AREA
*1903 IMPERIAL AREA
*1903 INDIO AREA
*1924 KING CITY AREA
*1946 KINGS
*1922 LANCASTER AREA
*1910 LIVERMORE AREA
*1937 LODI AREA
*1903 LOS ANGELES AREA
*1916 LOS ANGELES AREA
1952 LOS BANOS AREA
*1901 LOWER SALINAS VALLEY AREA
*1915 LOWER SAN JOAQUIN VALLEY
*1910 MADERA AREA
*1962 MADERA AREA
1974 MARIPOSA AREA
*1909 MARYSVILLE AREA
1956 MENDOTA AREA
*1914 MERCED AREA
1962 MERCED AREA
*1916 MIDDLE SAN JOAQUIN VALLEY AREA
*1908 MODESTO-TURLOCK AREA
*1938 NAPA AREA
1975 NEVADA AREA
1948 NEWMAN AREA
*1929 OCEANSIDE AREA
*1926 OROVILLE AREA
*1908 PAJARO VALLEY AREA
*1922 PALO VERDE AREA
1974 PALO VERDE AREA
*1915 PASADENA AREA
*1928 PASO ROBLEA AREA
*1942 PIXLEY AREA
*1927 PLACERVILLE AREA
*1908 PORTERSVILLE AREA
*1910 RED BLUFF AREA
*1907 REDDING AREA
*1915 RIVERSIDE AREA
*1904 SACRAMENTO AREA
*1941 SACRAMENTO AREA
*1954 SACRAMENTO AREA
*1941 SACRAMENTO SAN JOAQUIN DELTA AREA
*1913 SACRAMENTO VALLEY AREA
*1925 SALINAS AREA
1969 SAN BENITO
*1904 SAN BERNARDINO AREA
*1915 SAN DIEGO AREA
1973 SAN DIEGO AREA
*1915 SAN FERNANDO VALLEY AREA
*1914 SAN FRANCISCO BAY AREA
*1901 SAN GABRIEL AREA
*1903 SAN JOSE AREA
*1928 SAN LUIS OBISPO AREA
1961 SAN MATEO AREA
*1900 SANTA ANNA AREA
*1958 SANTA BARBARA AREA
1972 SANTA BARBARA AREA (NORTHERN)
1958 SANTA CLARA AREA
*1944 SANTA CRUZ AREA
*1916 SANTA MARIA AREA
*1927 SANTA YNEZ AREA
1974 SHASTA AREA
*1919 SHASTA VALLEY AREA
1975 SIERRA VALLEY AREA
1972 SONOMA
*1905 STOCKTON AREA
1951 STOCKTON AREA
*1930 SUISAN AREA
1974 SURPRISE VALLEY-HOME CAMP AREA
1974 TAHOE BASIN AREA
1967 TEHAMA
*1943 TRACY AREA
*1914 UKIAH AREA
*1917 UPPER SAN JOAQUIN VALLEY AREA
*1901 VENTURA AREA
*1917 VENTURA AREA
1970 VENTURA AREA
*1921 VICTORVILLE AREA
*1940 VISALIA AREA
1942 WASCO AREA
1971 WESTERN RIVERSIDE AREA
*1918 WILLITS AREA
*1909 WOODLAND AREA
1972 YOLO
*1904 YUMA AREA
*1929 YUMA-WELTON AREA

COLORADO

1974 ADAMS
1947 AKRON AREA
1973 ALAMOSA AREA
1971 ARAPAHOE
*1926 ARKANSAS VALLEY AREA
1973 BACA
1971 BENT
1975 BOULDER
*1932 BRIGHTON AREA
*1899 CACHE LA POUDRE VALLEY AREA
1974 CASTLE ROCK AREA
1975 CHAFFEE LAKE AREA
1968 CROWLEY
*1967 DELTA-MONTROSE AREA
1966 ELBERT(EASTERN PART)
*1927 FORT COLLINS AREA
*1962 FRASER-ALPINE AREA
*1905 GRAND JUNCTION AREA
1955 GRAND JUNCTION AREA
*1904 GREELEY AREA
*1929 GREELEY AREA
1975 GUNNISON AREA
*1930 LONGMONT AREA
*1902 LOWER ARKANSAS VALLEY AREA
1968 MORGAN
1972 OTERO
1971 PHILLIPS
1966 PROWERS
*1903 SAN LUIS VALLEY AREA
1970 SEDGWICH
1961 TROUT CREEK WATERSHED
*1910 UNCOMPAHGRE VALLEY AREA

CONNECTICUT

*1899 CONNECTICUT VALLEY AREA
*1903 CONNECTICUT VALLEY AREA
1962 HARTFORD
1970 LITCHFIELD
*1912 NEW LONDON
1966 TOLLAND
*1911 WINDHAM

DELAWARE

*1903 DOVER AREA
*1918 KENT
1971 KENT
*1915 NEW CASTLE
1970 NEW CASTLE
*1920 SUSSEX
1974 SUSSEX

FLORIDA

*1954 ALACHUA
*1913 BRADFORD
1974 BREVARD
1954 COLLIER
1958 DADE
*1921 DUVAL
*1906 ESCAMBIA
1960 ESCAMBIA
*1918 FLAGLER
*1915 FORT LAUDERDALE AREA
*1915 FRANKLIN
*1903 GADSDEN
1962 GADSDEN
*1904 GAINESVILLE AREA
*1914 HERNANDO
*1916 HILLSBOROUGH
1958 HILLSBOROUGH
1975 HOLMES
*1913 INDIAN RIVER AREA
*1910 JACKSONVILLE AREA
*1907 JEFFERSON
*1923 LAKE
1975 LAKE AREA
*1905 LEON
1958 MANATEE
*1909 MARIANNA AREA
*1912 OCALA AREA
1975 OCALA NATIONAL FOREST AREA
1971 OKEECHOBEE
*1919 ORANGE
1960 ORANGE
*1913 PINELLAS
1972 PINELLAS
*1927 POLK
*1914 PUTNAM
1959 SARASOTA
1966 SEMINOLE
*1917 ST. JOHNS

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1965 SUWANNEE
1965 WASHINGTON

GEORGIA

1975 APPLING AND JEFF DAVIS
*1904 BAINBRIDGE AREA
1971 BANKS AND STEPHENS
*1941 BARTOW
*1912 BEN HILL
1969 BEN HILL-IRWIN
1973 BERRIEN AND LANIER
*1922 BIBB
*1916 BROOKS
1974 BRYAN AND CHATHAM
*1910 BULLOCH
1968 BULLOCH
*1917 BURKE
*1919 BUTTS AND HENRY
*1925 CALHOUN
*1948 CANDLER
*1921 CARROLL
1971 CARROLL AND HARALSON
*1941 CATOOSA
*1911 CHATHAM
*1924 CHATTAHOOCHEE
*1912 CHATTOOGA
1973 CHEROKEE, GILMER AND PICKENS
*1927 CLARKE
1968 CLARKE-OCONEE
*1914 CLAY
*1901 COBB
1973 COBB
*1914 COLQUITT
1975 COLQUITT & COOK
*1911 COLUMBIA
*1928 COOK
*1901 COVINGTON AREA
*1919 COWETA AND FAYETTE
*1916 CRISP
*1942 DADE
1972 DAWSON, LUMPKIN, AND WHITE
*1939 DECATUR
*1914 DEKALB
*1904 DODGE
1923 DOOLY
*1912 DOUGHERTY
1968 DOUGHERTY
1961 DOUGLAS
*1918 EARLY
*1928 ELBERT
*1923 FANNIN
*1917 FLOYD
1960 FORSYTH
*1903 FORT VALLEY AREA
*1909 FRANKLIN
1958 FULTON
*1911 GLYNN
*1923 GORDON
1965 GORDON
*1908 GRADY
1967 GWINNETT
*1923 HABERSHAM
1963 HABERSHAM
*1941 HALL
*1909 HANCOCK
*1929 HART
1963 HART
1967 HOUSTON AND PEACH
*1914 JACKSON
*1916 JASPER
*1913 JEFF DAVIS
*1930 JEFFERSON
*1923 JENKINS
1968 JENKINS
*1913 JONES
*1925 LAMAR
1972 LAMAR, PIKE, AND UPSON
*1915 LAURENS
*1927 LEE
*1917 LOWNDES
*1918 MADISON
*1937 MCDUFFIE
*1929 MCINTOSH
1961 MCINTOSH
*1916 MERIWETHER
1965 MERIWETHER
*1913 MILLER
*1920 MITCHELL
*1920 MONROE
1973 MONTGOMERY, TOOMBS AND WHEELER
1965 MORGAN
*1922 MUSCOGEE
*1919 OCONEE, MORGAN, AND PUTNAM
*1918 PIERCE
1968 PIERCE
*1909 PIKE
*1914 POLK
*1918 PULASKI
*1926 QUITMAN
*1920 RABUN
*1924 RANDOLPH
*1912 RECONNAISSANCE TATTNALL
*1916 RICHMOND
*1920 ROCKDALE
1974 SCHLEY AND SUMTER
*1920 SCREVEN
*1905 SPALDING
1964 SPALDING
*1913 STEWART
*1910 SUMTER
*1913 TALBOT
*1914 TATTNALL
1914 TERRELL
*1908 THOMAS
*1909 TIFT
1959 TIFT
*1939 TOOMBS
*1954 TOWNS
1964 TREUTLEN
*1912 TROUP
*1915 TURNER
1963 TWIGGS
1950 UNION
*1910 WALKER
1964 WALTON
*1915 WASHINGTON
*1906 WAYCROSS AREA
*1926 WAYNE
1965 WAYNE
*1915 WILKES
*1929 WORTH

HAWAII

1973 ISLAND OF HAWAII
1972 KAUAI, OAHU, MAUI, MOLOKAI, AND LANAI
1955 THE TERRITORY OF HAWAII

IDAHO

*1926 BEAR LAKE VALLEY AREA
*1930 BENEWAH
1973 BINGHAM
*1903 BLACKFOOT AREA
1943 BLACKFOOT-ABERDEEN AREA
*1901 BOISE AREA
*1939 BONNER
1972 CANYON AREA
1965 GEM COUNTY AREA
*1929 GOODING AREA
1950 IDAHO FALLS AREA
*1927 JEROME AREA
1971 KOOSKIA
*1919 KOOTENAI
*1915 LATAH
*1902 LEWISTON AREA
*1907 MINIDOKA AREA
*1923 MINIDOKA AREA
1975 MINIDOKA AREA
*1917 NEZ PERCE AND LEWIS
*1918 PORTNEUF AREA
*1925 SODA SPRINGS BANCROFF AREA
1969 TETON AREA IDAHO-WYOMING
*1921 TWIN FALLS AREA

ILLINOIS

*1902 CLAY
*1902 CLINTON
1971 DOUGLAS
1972 EDWARDS AND RICHLAND
1969 GALLATIN
1974 GREENE
1956 HENDERSON(STATE)
1966 JERSEY(STATE)
*1903 JOHNSON
1964 JOHNSON(STATE)
*1903 KNOX
1970 LAKE
1972 LASALLE(STATE)
1956 LAWRENCE(STATE)
1974 LOGAN
1965 MCHENRY(STATE)
*1903 MCLEAN
1953 MENARD(STATE)
1969 MONTGOMERY
*1904 O'FALLON AREA
1975 POPE, HARDIN & MASSAC
1968 PULASKI AND ALEXANDER
*1903 SANGAMON
*1902 ST. CLAIR
*1902 TAZEWELL
1964 WABASH
*1912 WILL
1962 WILL(STATE)
1959 WILLIAMSON(STATE)
*1903 WINNEBAGO

INDIANA

1921 ADAMS
*1908 ALLEN
1969 ALLEN
1947 BARTHOLOMEW
1916 BENTON
*1928 BLACKFORD
*1912 BOONE
1975 BOONE
*1904 BOONEVILLE AREA
1946 BROWN
1958 CARROLL
*1955 CASS
1974 CLARK AND FLOYD
1922 CLAY
*1914 CLINTON
1975 CRAWFORD
1974 DAVIESS
1910 DECATUR
*1913 DELAWARE
1972 DELAWARE
1937 DUBOIS
*1914 ELKHART
1974 ELKHART
1960 FAYETTE AND UNION
1966 FOUNTAIN
1950 FRANKLIN
1946 FULTON

* OUT OF PRINT : NOT AVAILABLE FOR DISTRIBUTION

1922 GIBSON
*1915 GRANT
*1906 GREENE
*1912 HAMILTON
1925 HANCOCK
1975 HARRISON
1913 HENDRICKS
1974 HENDRICKS
1971 HOWARD
1940 JENNINGS
1948 JOHNSON
1943 KNOX
1922 KOSCIUSKO
1944 LA PORTE
*1917 LAKE
1972 LAKE
*1922 LAWRENCE
*1903 MADISON
1967 MADISON
*1907 MARION
*1904 MARSHALL
1946 MARTIN
1927 MIAMI
*1922 MONROE
*1912 MONTGOMERY
1950 MORGAN
*1905 NEWTON
1955 NEWTON
*1953 NOBLE
1930 OHIO AND SWITZERLAND
1964 OWEN
1967 PARKE
1969 PERRY
1938 PIKE
*1916 PORTER
*1902 POSEY
1968 PULASKI
1925 PUTNAM
1931 RANDOLPH
*1937 RUSH
*1904 SCOTT
1962 SCOTT
1974 SHELBY
1973 SPENCER
1950 ST. JOSEPH
*1915 STARKE
1940 STEUBEN
1971 SULLIVAN
*1905 TIPPECANOE
1959 TIPPECANOE
*1912 TIPTON
1944 VANDERBURGH
1930 VERMILLION
1974 VIGO
*1914 WARREN
1939 WASHINGTON
1925 WAYNE
*1915 WELLS
*1915 WHITE

IOWA

*1919 ADAIR
1963 ADAMS
1958 ALLAMAKEE
*1923 APPANOOSE
1940 AUDUBON
*1921 BENTON
*1917 BLACK HAWK
*1920 BOONE
*1913 BREMER
1967 BREMER
*1926 BUCHANAN
*1917 BUENA VISTA
*1928 BUTLER
1930 CALHOUN
*1926 CARROLL
1969 CASS
1919 CEDAR
*1903 CERRO GORDO
1940 CERRO GORDO
*1924 CHEROKEE
*1927 CHICKASAW
1923 CLARKE
*1916 CLAY
1969 CLAY
*1925 CLAYTON
*1915 CLINTON
*1928 CRAWFORD
1973 CRAWFORD
*1920 DALLAS
1940 DAVIS
1939 DECATUR
*1922 DELAWARE
*1921 DES MOINES
*1920 DICKINSON
*1921 DUBUQUE
*1902 DUBUQUE AREA
*1920 EMMET
*1919 FAYETTE
*1922 FLOYD
*1938 FRANKLIN
*1924 FREMONT
1975 FREMONT
*1921 GREENE
*1921 GRUNDY
*1929 GUTHRIE
1974 GUTHRIE
*1917 HAMILTON
1930 HANCOCK
*1920 HARDIN
*1923 HARRISON
*1917 HENRY
1935 HOWARD
1974 HOWARD
1961 HUMBOLDT
1939 IDA
1967 IOWA
1941 JACKSON
*1921 JASPER
*1922 JEFFERSON
1960 JEFFERSON
*1919 JOHNSON
*1924 JONES
1971 KEOKUK
*1925 KOSSUTH
*1914 LEE
1917 LINN
1975 LINN
*1918 LOUISA
1960 LUCAS
1927 LYON
*1918 MADISON
1975 MADISON
*1919 MAHASKA
1939 MARION
*1919 MARSHALL
1920 MILLS
*1916 MITCHELL
1975 MITCHELL
1959 MONONA
1931 MONROE
*1917 MONTGOMERY
*1914 MUSCATINE
*1921 O'BRIEN
1940 OSCEOLA
*1921 PAGE
*1918 PALO ALTO
*1923 PLYMOUTH
1928 POCAHONTAS
*1918 POLK
1960 POLK
*1914 POTTAWATTAMIE
1929 POWESHIEK
*1916 RINGGOLD
1924 SAC
*1915 SCOTT
1961 SHELBY
*1915 SIOUX
*1903 STORY
1941 STORY
*1904 TAMA
1950 TAMA
1954 TAYLOR
*1927 UNION
*1915 VAN BUREN
1962 VAN BUREN
*1917 WAPELLO
*1925 WARREN
1930 WASHINGTON
*1918 WAYNE
1971 WAYNE
*1914 WEBSTER
1975 WEBSTER
*1918 WINNEBAGO
*1922 WINNESHIEK
1968 WINNESHIEK
*1920 WOODBURY
1972 WOODBURY
1922 WORTH
*1919 WRIGHT

KANSAS

*1904 ALLEN
*1938 ALLEN
1931 BOURBON
*1905 BROWN
1960 BROWN
1975 BUTLER
1974 CHASE
*1912 CHEROKEE
1926 CLAY
*1915 COWLEY
*1928 CRAWFORD
1973 CRAWFORD
*1927 DONIPHAN
1973 EDWARDS
1975 ELLIS
1965 FINNEY
1965 FORD
*1904 GARDEN CITY AREA
1960 GEARY
1969 GRANT
1968 GRAY
1961 GREELEY
*1912 GREENWOOD
1961 HAMILTON
1971 HARPER
1974 HARVEY
1968 HASKELL
1973 HODGEMAN
*1912 JEWELL
1928 JOHNSON
1963 KEARNY
1938 KINGMAN
*1926 LABETTE
1972 LANE
*1919 LEAVENWORTH
1964 LOGAN
1930 MARION
*1913 MONTGOMERY
1974 MORRIS
1963 MORTON
*1930 NEOSHO
*1903 PARSONS AREA
1968 PRATT
*1911 RENO
1966 RENO
1967 REPUBLIC
1974 RICE
*1906 RILEY
1975 RILEY & PART OF GEARY
*1903 RUSSELL

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1959 SALINE
1965 SCOTT
1965 SEWARD
*1911 SHAWNEE
1970 SHAWNEE
1973 SHERMAN
1961 STANTON
1961 STEVENS
*1910 WESTERN KANSAS RECONNAISSANCE
1965 WICHITA
*1902 WICHITA AREA
*1927 WILSON
1931 WOODSON

KENTUCKY

1964 ADAIR
1969 BARREN
1963 BATH
1973 BOONE, CAMPBELL AND KENTON
1966 CALDWELL
1945 CALLOWAY
1973 CALLOWAY AND MARSHALL
*1912 CHRISTIAN
1964 CLARK
1974 DAVIESS & HANCOCK
1965 ELLIOTT
1974 ESTILL AND LEE
*1931 FAYETTE
1968 FAYETTE
1965 FOURTEEN CO. EASTERN KY. RECONNAISSANCE
1964 FULTON
*1921 GARRARD
1953 GRAVES
1972 GRAYSON
1968 HARRISON
1967 HENDERSON
1966 JEFFERSON
*1915 JESSAMINE
*1919 LOGAN
1975 LOGAN
*1905 MADISON
1973 MADISON
1950 MARSHALL
*1903 MASON
1970 MC CREARY-WHITLEY AREA
*1905 MCCRACKEN
1974 MENIFEE AND ROWAN AND NORTHWESTERN MORGAN
1930 MERCER
1967 METCALFE
1920 MUHLENBERG
1971 NELSON
1974 PULASKI
*1910 ROCKCASTLE
*1903 SCOTT
1916 SHELBY
*1902 UNION
*1904 WARREN

LOUISIANA

*1903 ACADIA
1962 ACADIA
*1928 BEAUREGARD
*1908 BIENVILLE
1962 BOSSIER
*1906 CADDO
*1910 CONCORDIA
*1904 DE SOTO
*1908 EAST AND WEST CARROLL
*1906 EAST BATON ROUGE
1968 EAST BATON ROUGE
*1912 EAST FELICIANA
1974 EVANGELINE
*1911 IBERIA
*1918 LA SALLE
*1915 LAFAYETTE
*1901 LAKE CHARLES AREA
*1909 LINCOLN
*1931 LIVINGSTON
*1921 NATCHITOCHES
*1903 NEW ORLEANS AREA
*1903 OUACHITA
1974 OUACHITA
*1916 RAPIDES
*1919 SABINE
1973 ST. JAMES AND ST. JOHN THE BAPTIST
*1917 ST. MARTIN
1959 ST. MARY
*1905 TANGIPAHOA
1968 TENSAS
1960 TERREBONNE
*1922 WASHINGTON
*1914 WEBSTER
*1907 WINN

MAINE

1970 ANDROSCOGGIN AND SAGADAHOC
*1917 AROOSTOOK
1964 AROOSTOOK NORTHEASTERN PART
1964 AROOSTOOK SOUTHERN PART
*1908 CARIBOU AREA
*1915 CUMBERLAND
1974 CUMBERLAND
*1909 ORONO AREA
1963 PENOBSCOT
1972 SOMERSET(SOUTHERN PART)
*1955 WALDO
*1952 YORK

MARYLAND

*1921 ALLEGANY
*1909 ANNE ARUNDEL
*1929 ANNE ARUNDEL
1973 ANNE ARUNDEL
*1917 BALTIMORE
*1900 CALVERT
*1928 CALVERT
1971 CALVERT
*1929 CAROLINE
1964 CAROLINE
*1919 CARROLL
1969 CARROLL
*1900 CECIL
*1927 CECIL
1973 CECIL
*1918 CHARLES
1974 CHARLES
*1922 DORCHESTER
*1963 DORCHESTER
*1907 EASTON AREA
*1919 FREDERICK
1960 FREDERICK
*1922 GARRETT
1974 GARRETT
*1901 HARFORD
*1927 HARFORD
1975 HARFORD AREA
*1916 HOWARD
1968 HOWARD
*1900 KENT
*1930 KENT
*1914 MONTGOMERY
1961 MONTGOMERY
*1901 PRINCE GEORGES
*1925 PRINCE GEORGES
1967 PRINCE GEORGES
*1931 QUEEN ANNES
1966 QUEEN ANNES
*1920 SOMERSET
1966 SOMERSET
*1900 ST. MARYS
*1923 ST. MARYS
*1929 TALBOT
1970 TALBOT
*1917 WASHINGTON
1962 WASHINGTON
*1921 WICOMICO
1970 WICOMICO
*1903 WORCESTER
*1924 WORCESTER
1973 WORCESTER

MASSACHUSETTS

*1923 BERKSHIRE
*1899 CONNECTICUT VALLEY AREA
*1903 CONNECTICUT VALLEY AREA
*1925 DUKES AND NANTUCKET
*1925 ESSEX
*1929 FRANKLIN
1967 FRANKLIN
*1928 HAMPDEN AND HAMPSHIRE
*1924 MIDDLESEX
*1920 NORFOLK, BRISTOL, AND BARNSTAL
*1911 PLYMOUTH
1969 PLYMOUTH
*1922 WORCESTER

MICHIGAN

1929 ALGER
*1901 ALLEGAN
*1904 ALMA AREA
1924 ALPENA
1923 ANTRIM
1967 ARENAC
*1924 BARRY
1931 BAY
*1902 BERRIEN
*1928 BRANCH
*1916 CALHOUN
*1906 CASS
1974 CHARLEVOIX
1939 CHEBOYGAN
1927 CHIPPEWA
1942 CLINTON
1927 CRAWFORD
*1930 EATON
1973 EMMET
*1912 GENESEE
1972 GENESEE
1972 GLADWIN
1966 GRAND TRAVERSE
1924 HILLSDALE
1941 INGHAM
1967 IONIA
1937 IRON
1925 ISABELLA
1926 JACKSON
*1922 KALAMAZOO
1927 KALKASKA
1926 KENT
1972 LAPEER
1973 LEELANAU
1961 LENAWEE
*1923 LIVINGSTON
1974 LIVINGSTON
1929 LUCE
*1923 MACOMB
1971 MACOMB
1922 MANISTEE
1939 MASON
*1927 MECOSTA

* OUT OF PRINT ; NOT AVAILABLE FOR DISTRIBUTION

1925 MENOMINEE
1950 MIDLAND
1960 MONTCALM
1930 MONTMORENCY
*1904 MUNISING AREA
*1924 MUSKEGON
1968 MUSKEGON
1951 NEWAYGO
*1938 OCEANA
1923 OGEMAW
1969 OSCEOLA
1931 OSCODA
*1922 OTTAWA
1972 OTTAWA
*1904 OWOSSO AREA
*1905 OXFORD AREA
*1903 PONTIAC AREA
*1940 PRESQUE ISLE
*1921 RECONNAISSANCE ONTONAGON
1924 ROSCOMMON
1938 SAGINAW
*1904 SAGINAW AREA
1961 SANILAC
1939 SCHOOLCRAFT
1974 SHIAWASSEE
*1929 ST. CLAIR
1974 ST. CLAIR
*1921 ST. JOSEPH
1926 TUSCOLA
*1922 VAN BUREN
1930 WASHTENAW
*1908 WEXFORD

MINNESOTA

*1916 ANOKA
*1906 BLUE EARTH
*1905 CARLTON AREA
1968 CARVER
*1906 CROOKSTON AREA
1965 CROW WING
1960 DAKOTA
1961 DODGE
1975 DOUGLAS
1957 FARIBAULT
1958 FILLMORE
*1913 GOODHUE
*1929 HENNEPIN
1974 HENNEPIN
*1929 HOUSTON
1930 HUBBARD
1958 ISANTI
*1923 JACKSON
1939 KANABEC
*1924 LAC QUE PARLE
1926 LAKE OF THE WOODS (RECONNAISSANCE)
1954 LE SUEUR
1970 LINCOLN
*1903 MARSHALL AREA
1955 MCLEOD
1927 MILLE LACS
1958 NICOLLET
1975 NOBLES
1974 NORMAN
*1923 OLMSTED
*1914 PENNINGTON
*1941 PINE
1972 POPE
*1914 RAMSEY
*1939 RED RIVER VALLEY AREA
*1909 RICE
1975 RICE
1949 ROCK
1942 ROSEAU
1959 SCOTT
1968 SHERBURNE
1973 STEELE
*1919 STEVENS
1971 STEVENS
1973 SWIFT
1965 WABASHA
*1926 WADENA
1965 WASECA
1968 WRIGHT

MISSISSIPPI

*1910 ADAMS
1970 ADAMS
*1921 ALCORN
1971 ALCORN
*1917 AMITE
*1904 BILOXI AREA
1958 BOLIVAR
1965 CALHOUN
*1915 CHICKASAW
1974 CHICKASAW
*1920 CHOCTAW
*1926 CLAIBORNE
1963 CLAIBORNE
*1914 CLARKE
1965 CLARKE
*1909 CLAY
*1915 COAHOMA
1959 COAHOMA
*1918 COVINGTON
1965 COVINGTON
*1905 CRYSTAL SPRINGS AREA
1959 DE SOTO
*1911 FORREST
*1922 GEORGE
1971 GEORGE
*1932 GREENE
*1915 GRENADA
1967 GRENADA
*1930 HANCOCK
*1924 HARRISON
1975 HARRISON
*1916 HINDS
*1908 HOLMES
1959 HUMPHREYS
1961 ISSAQUENA
*1927 JACKSON
1964 JACKSON
*1904 JACKSON AREA
*1907 JASPER
*1915 JEFFERSON DAVIS
*1913 JONES
*1912 LAFAYETTE
*1919 LAMAR
1975 LAMAR
*1910 LAUDERDALE
*1916 LEE
1973 LEE
1959 LEFLORE
*1912 LINCOLN
1963 LINCOLN
*1911 LOWNDES
*1917 MADISON
*1938 MARION
1972 MARSHALL
*1903 MCNEILL AREA
*1908 MONROE
1966 MONROE
*1906 MONTGOMERY
1975 MONTGOMERY
*1916 NEWTON
1960 NEWTON
*1910 NOXUBEE
*1907 OKTIBBEHA
1973 OKTIBBEHA
1963 PANOLA
*1918 PEARL RIVER
*1922 PERRY
*1918 PIKE
1968 PIKE
*1906 PONTOTOC
1973 PONTOTOC
*1907 PRENTISS
1957 PRENTISS
1958 QUITMAN
*1926 RANKIN
*1909 SCRANTON AREA
1962 SHARKEY
*1919 SIMPSON
*1902 SMEDES AREA
*1920 SMITH
1959 SUNFLOWER
1970 TALLAHATCHIE
1967 TATE
1966 TIPPAH
*1944 TISHOMINGO
1956 TUNICA
1968 WALTHALL
*1912 WARREN
1964 WARREN
1961 WASHINGTON
*1911 WAYNE
*1913 WILKINSON
*1912 WINSTON
1975 YAZOO
*1901 YAZOO AREA

MISSOURI

*1921 ANDREW
*1909 ATCHISON
*1916 BARRY
*1912 BARTON
1974 BARTON
*1908 BATES
1962 BOONE
*1915 BUCHANAN
*1921 CALDWELL
1974 CALDWELL
*1916 CALLAWAY
*1910 CAPE GIRARDEAU
*1912 CARROLL
*1912 CASS
*1909 CEDAR
*1918 CHARITON
*1920 COLE
*1909 COOPER
*1905 CRAWFORD
1964 DAVIESS
*1914 DE KALB
1971 DENT
*1914 DUNKLIN
*1911 FRANKLIN
*1913 GREENE
*1914 GRUNDY
*1914 HARRISON
*1953 HOLT
*1902 HOWELL
*1910 JACKSON
1954 JASPER
*1914 JOHNSON
*1917 KNOX
*1911 LACLEDE
*1920 LAFAYETTE
1975 LAFAYETTE
*1923 LAWRENCE
*1917 LINCOLN
*1945 LINN
1956 LIVINGSTON
*1911 MACON
*1910 MARION
1975 MARK TWAIN NATIONAL FOREST AREA
*1912 MILLER
*1921 MISSISSIPPI
1964 MONITEAU
*1915 NEWTON

* OUT OF PRINT : NOT AVAILABLE FOR DISTRIBUTION

*1913 NODAWAY
*1904 O'FALLON AREA
*1910 PEMISCOT
1971 PEMISCOT
*1913 PERRY
*1914 PETTIS
*1912 PIKE
*1911 PLATTE
*1926 POLK
*1906 PUTNAM
*1913 RALLS
*1922 RAY
*1911 RECONNAISSANCE OZARK REGION
*1918 REYNOLDS
*1915 RIPLEY
*1919 SALINE
*1905 SCOTLAND
1975 SCOTLAND
*1903 SHELBY
*1956 ST. CHARLES
*1918 ST. FRANCOIS
*1919 ST. LOUIS
*1912 STODDARD
*1917 TEXAS
*1904 WEBSTER
1968 WORTH

MONTANA

1944 BIG HORN VALLEY AREA
*1902 BILLINGS AREA
*1914 BITTERROOT VALLEY AREA
1959 BITTERROOT VALLEY AREA
1975 CARBON AREA
1953 CENTRAL MONTANA (RECONNAISSANCE)
*1905 GALLATIN VALLEY AREA
*1931 GALLATIN VALLEY AREA
1967 JUDITH BASIN AREA
*1929 LOWER FLATHEAD VALLEY AREA
1939 LOWER YELLOWSTONE VALLEY AREA
1940 MIDDLE YELLOWSTONE VALLEY AREA
*1928 MILK RIVER AREA
*1929 NORTHERN PLAINS OF MONTANA RECONNAISSANCE
1971 POWDER RIVER AREA
1967 TREASURE
1960 UPPER FLATHEAD VALLEY AREA
1943 UPPER MUSSELSHELL VALLEY AREA
1958 WIBAUX
1972 YELLOWSTONE

NEBRASKA

*1923 ADAMS
1974 ADAMS
*1921 ANTELOPE
*1919 BANNER
*1954 BLAINE
*1921 BOONE
1972 BOONE
*1916 BOX BUTTE
*1937 BOYD
*1938 BROWN
*1924 BUFFALO
1974 BUFFALO
*1922 BURT
*1924 BUTLER
*1913 CASS
*1941 CASS
*1928 CEDAR
*1917 CHASE
1956 CHERRY
*1918 CHEYENNE
*1927 CLAY
*1930 COLFAX
*1922 CUMING
1975 CUMING
*1926 CUSTER
*1919 DAKOTA
*1915 DAWES
*1922 DAWSON
*1921 DEUEL
1965 DEUEL
*1929 DIXON
*1916 DODGE
*1913 DOUGLAS
1975 DOUGLAS & SARPY
*1931 DUNDY
1963 DUNDY
*1916 FILLMORE
*1916 FORT LARAMIE AREA
*1926 FRANKLIN
*1939 FRONTIER
*1930 FURNAS
*1914 GAGE
1964 GAGE
*1924 GARDEN
*1938 GARFIELD
*1938 GOSPER
*1903 GRAND ISLAND AREA
*1937 GREELEY
*1916 HALL
1962 HALL
*1927 HAMILTON
*1930 HARLAN
1974 HARLAN
*1938 HAYES
*1930 HITCHCOCK
1970 HITCHCOCK
*1938 HOLT
1964 HOOKER
*1920 HOWARD
1974 HOWARD
*1921 JEFFERSON
1975 JEFFERSON
*1920 JOHNSON
*1923 KEARNEY
*1904 KEARNEY AREA
*1926 KEITH
*1937 KEYA PAHA
*1916 KIMBALL
1962 KIMBALL
*1930 KNOX
*1906 LANCASTER
1948 LANCASTER
*1926 LINCOLN
1975 LOGAN
*1937 LOUP
*1920 MADISON
1969 MCPHERSON
*1922 MERRICK
*1917 MORRILL
*1922 NANCE
1960 NANCE
*1914 NEMAHA
*1907 NORTH PLATTE AREA
*1925 NUCKOLLS
*1912 OTOE
1950 OTOE
*1920 PAWNEE
*1921 PERKINS
*1917 PHELPS
1973 PHELPS
*1928 PIERCE
*1923 PLATTE
*1915 POLK
1974 POLK
*1919 RED WILLOW
1967 RED WILLOW
*1915 RICHARDSON
1974 RICHARDSON
*1937 ROCK
*1928 SALINE
*1905 SARPY
*1939 SARPY
*1913 SAUNDERS
1965 SAUNDERS
*1913 SCOTTS BLUFF
1968 SCOTTS BLUFF
*1914 SEWARD
1974 SEWARD
*1918 SHERIDAN
*1931 SHERMAN
*1919 SIOUX
*1929 STANTON
*1903 STANTON AREA
*1927 THAYER
1968 THAYER
1965 THOMAS
*1914 THURSTON
1972 THURSTON
*1932 VALLEY
*1915 WASHINGTON
1964 WASHINGTON
*1917 WAYNE
1975 WAYNE
*1923 WEBSTER
1974 WEBSTER
*1911 WESTERN NEBRASKA RECONNAISSANCE
*1937 WHEELER
*1928 YORK

NEVADA

1971 CARSON VALLEY AREA
*1909 FALLON AREA
1975 FALLON-FERNLEY AREA
1967 LAS VEGAS AND ELDORADO VALLEYS AREA
*1923 LAS VEGAS AREA
1965 LOVELOCK AREA
*1923 MOAPA VALLEY AREA
1968 PAHRANAGAT-PENOYER AREA
1974 SURPRISE VALLEY-HOME CAMP
1974 TAHOE BASIN

NEW HAMPSHIRE

1968 BELKNAP
1949 CHESHIRE AND SULLIVAN
1943 COOS
1939 GRAFTON
1953 HILLSBORO
*1906 MERRIMACK
1965 MERRIMACK
*1909 NASHUA AREA
1959 ROCKINGHAM
1949 STRAFFORD
1973 STRAFFORD

NEW JERSEY

*1917 BELVIDERE AREA
1925 BERGEN AREA
*1919 BERNARDSVILLE AREA
1971 BURLINGTON
1966 CAMDEN
*1915 CAMDEN AREA
1926 CAMDEN AREA
*1919 CHATSWORTH AREA
*1913 FREEHOLD AREA
*1927 FREEHOLD AREA
1962 GLOUCESTER
1974 HUNTERDON
1972 MERCER

* OUT OF PRINT ; NOT AVAILABLE FOR DISTRIBUTION

*1917 MILLVILLE AREA
1975 PASSAIC
1969 SALEM
*1901 SALEM AREA
*1923 SALEM AREA
1975 SUSSEX
*1911 SUSSEX AREA
*1902 TRENTON AREA
*1921 TRENTON AREA

NEW MEXICO

1958 BLUEWATER AREA
1968 CABEZON AREA
1958 CURRY
*1928 DEMING AREA
1971 EDDY AREA
*1930 FORT SUMNER AREA
1973 HARDING
1973 HIDALGO
1974 LEA
*1932 LOVINGTON AREA
*1912 MESILLA VALLEY AREA
*1912 MIDDLE RIO GRANDE VALLEY AREA
*1899 PECOS VALLEY
1959 PORTALES AREA
*1930 RINCON AREA
1967 ROOSEVELT
*1933 ROSWELL AREA
1975 SANTA FE AREA
*1929 SOCORRO AND RIO PUERCO AREAS
1960 SOUTHWEST QUAY AREA
*1950 THE DUNCAN AREA
1970 TORRANCE AREA
1974 TUCUMCARI AREA
1975 VALENCIA
1967 ZUNI MOUNTAIN AREA

NEW YORK

1942 ALBANY AND SCHENECTADY
1956 ALLEGANY
*1904 AUBURN AREA
*1902 BIGFLATS AREA
*1905 BINGHAMPTON AREA
*1932 BROOME
1971 BROOME
*1940 CATTARAUGUS
*1922 CAYUGA
1971 CAYUGA
*1914 CHAUTAUQUA
*1932 CHEMUNG
1973 CHEMUNG
*1918 CHENANGO
*1914 CLINTON
*1923 COLUMBIA
*1916 CORTLAND
1961 CORTLAND
*1930 DELAWARE
*1907 DUTCHESS
1955 DUTCHESS
*1929 ERIE
1958 FRANKLIN
*1922 GENESEE
1969 GENESEE
1975 HERKIMER
*1923 HERKIMER AREA
*1911 JEFFERSON
1960 LEWIS
*1908 LIVINGSTON
1956 LIVINGSTON
*1903 LONG ISLAND AREA
*1902 LYONS AREA
*1906 MADISON
*1910 MONROE
*1938 MONROE
1973 MONROE
*1908 MONTGOMERY
*1906 NIAGARA
*1947 NIAGARA
1972 NIAGARA
*1913 ONEIDA
*1938 ONONDAGA
*1910 ONTARIO
1958 ONTARIO AND YATES
*1912 ORANGE
1939 ORLEANS
*1917 OSWEGO
1940 OTSEGO
1937 RENSSELAER
*1917 SARATOGA
*1915 SCHOHARIE
1969 SCHOHARIE
*1942 SENECA
1972 SENECA
1925 ST. LAWRENCE
*1931 STEUBEN
1975 SUFFOLK
*1928 SUFFOLK AND NASSAU
1946 SULLIVAN
*1903 SYRACUSE AREA
1953 TIOGA
*1905 TOMPKINS
*1920 TOMPKINS
1965 TOMPKINS
*1940 ULSTER
*1909 WASHINGTON
1975 WASHINGTON
*1919 WAYNE
*1901 WESTFIELD AREA
*1919 WHITE PLAINS AREA
*1938 WYOMING
1974 WYOMING
*1916 YATES

NORTH CAROLINA

*1901 ALAMANCE
1960 ALAMANCE
*1915 ALLEGHANY
1973 ALLEGHANY
*1915 ANSON
*1912 ASHE
*1903 ASHEVILLE AREA
1955 AVERY
*1917 BEAUFORT
*1918 BERTIE
*1914 BLADEN
1937 BRUNSWICK
*1920 BUNCOMBE
1954 BUNCOMBE
*1926 BURKE
*1910 CABARRUS
*1917 CALDWELL
*1923 CAMDEN AND CURRITUCK
*1938 CARTERET
*1901 CARY AREA
*1908 CASWELL
1975 CATAWBA
1937 CHATHAM
*1921 CHEROKEE
1951 CHEROKEE
*1906 CHOWAN
1941 CLAY
*1916 CLEVELAND
*1915 COLUMBUS
*1929 CRAVEN
*1903 CRAVEN AREA
*1922 CUMBERLAND
*1915 DAVIDSON
*1927 DAVIE
*1905 DUPLIN
1959 DUPLIN
*1920 DURHAM
*1907 EDGECOMBE
*1913 FORSYTH
1931 FRANKLIN
*1909 GASTON
*1929 GATES
1953 GRAHAM
*1910 GRANVILLE
*1924 GREENE
*1904 GREENVILLE AREA
*1920 GUILFORD
*1916 HALIFAX
*1916 HARNETT
*1922 HAYWOOD
*1954 HAYWOOD
*1907 HENDERSON
*1943 HENDERSON
*1916 HERTFORD
*1902 HICKORY AREA
*1918 HOKE
1964 IREDELL
*1948 JACKSON
*1911 JOHNSTON
*1938 JONES
*1909 LAKE MATTAMUSKEET AREA
*1933 LEE
1927 LENOIR
*1914 LINCOLN
1929 MACON
1956 MACON
*1942 MADISON
*1928 MARTIN
*1910 MECKLENBURG
*1952 MITCHELL
*1930 MONTGOMERY
*1919 MOORE
*1902 MT. MITCHELL AREA
*1926 NASH
*1906 NEW HANOVER
*1925 NORTHAMPTON
*1921 ONSLOW
*1918 ORANGE
*1937 PAMLICO
1957 PASQUOTANK
*1912 PENDER
*1905 PERQUIMANS AND PASQUOTANK
*1928 PERSON
*1909 PITT
1974 PITT
*1923 POLK
*1900 RALEIGH TO NEWBERN
*1913 RANDOLPH
*1911 RICHMOND
*1908 ROBESON
1926 ROCKINGHAM
*1914 ROWAN
*1924 RUTHERFORD
*1923 SAMPSON
*1909 SCOTLAND
1967 SCOTLAND
*1916 STANLY
*1901 STATESVILLE AREA
*1940 STOKES
*1937 SURRY
1947 SWAIN
*1906 TRANSYLVANIA
*1948 TRANSYLVANIA
1974 TRANSYLVANIA
*1920 TYRRELL
*1914 UNION
*1918 VANCE
*1914 WAKE
1970 WAKE
1942 WARREN
*1932 WASHINGTON
*1928 WATAUGA
1958 WATAUGA
*1915 WAYNE

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1974 WAYNE
*1918 WILKES
*1925 WILSON
*1924 YADKIN
1962 YADKIN
*1952 YANCEY

NORTH DAKOTA

*1912 BARNES
1944 BILLINGS
*1915 BOTTINEAU
1975 BOWMAN
1974 BURLEIGH
*1904 CANDO AREA
*1905 CARRINGTON AREA
*1924 CASS
*1914 DICKEY
*1903 FARGO AREA
*1902 GRAND FORKS AREA
*1903 JAMESTOWN AREA
*1914 LA MOURE
1971 LA MOURE AND PARTS OF JAMES RIVER VALLEY
*1921 MCHENRY
1942 MCKENZIE
*1907 MCKENZIE AREA
1951 MORTON
*1907 MORTON AREA
1975 OLIVER
*1906 RANSOM
*1908 RECONNAISSANCE WESTERN
*1908 RICHLAND
1975 RICHLAND CO. & SHEYENNE NAT. GRASSLAND AREA
*1917 SARGENT
1964 SARGENT
1968 STARK
1918 TRAILL
1966 TRI-COUNTY AREA
1972 WALSH
1974 WARD
1970 WELLS
*1906 WILLISTON AREA

OHIO

1938 ADAMS
1965 ALLEN
1973 ASHTABULA
*1903 ASHTABULA AREA
*1938 ATHENS
*1909 AUGLAIZE
*1927 BELMONT
*1930 BROWN
1927 BUTLER
1971 CHAMPAIGN
1958 CLARK
*1923 CLERMONT
1975 CLERMONT
*1905 CLEVELAND AREA
1962 CLINTON
1968 COLUMBIANA
*1902 COLUMBUS AREA
*1904 COSHOCTON
1969 DELAWARE
1971 ERIE
1960 FAIRFIELD
1973 FAYETTE
*1922 FULTON
*1915 GEAUGA
*1915 HAMILTON
1973 HANCOCK
1974 HENRY
1955 HURON
*1925 LAKE
1938 LICKING
1939 LOGAN
1934 LUCAS
*1917 MAHONING
1971 MAHONING
*1916 MARION
*1906 MEIGS
*1916 MIAMI
1974 MONROE
*1900 MONTGOMERY
*1925 MUSKINGUM
*1928 OTTAWA
*1914 PAULDING
1960 PAULDING
*1914 PORTAGE
1969 PREBLE
*1930 PUTNAM
1974 PUTNAM
*1912 RECONNAISSANCE OF STATE OF OHIO
1975 RICHLAND
1967 ROSS
*1917 SANDUSKY
1940 SCIOTO
*1913 STARK
1971 STARK
1974 SUMMIT
*1902 TOLEDO AREA
*1914 TRUMBULL
1954 TUSCARAWAS
1975 UNION
1972 VAN WERT
1938 VINTON
1973 WARREN
*1926 WASHINGTON
*1905 WESTERVILLE AREA
1966 WOOD
*1904 WOOSTER AREA

OKLAHOMA

1965 ADAIR
*1939 ALFALFA
1975 ALFALFA
1962 BEAVER
1968 BLAINE
*1914 BRYAN
1973 CADDO
*1917 CANADIAN
*1938 CARTER
1970 CHEROKEE AND DELAWARE
*1943 CHOCTAW
1960 CIMARRON
1954 CLEVELAND
1974 COAL
1967 COMANCHE
1963 COTTON
*1931 CRAIG
1973 CRAIG
1959 CREEK
1963 DEWEY
1966 ELLIS
*1939 GARFIELD
1967 GARFIELD
*1931 GRANT
*1937 GREER
1967 GREER
1960 HARPER
1975 HASKELL
1968 HUGHES
1961 JACKSON
1973 JEFFERSON
*1915 KAY
1967 KAY
1962 KINGFISHER
*1931 KIOWA
1931 LE FLORE
1970 LINCOLN
1960 LOGAN
1966 LOVE
*1940 MAJOR
1969 MAJOR
*1937 MAYES
1975 MAYES
1974 MCCURTAIN
*1938 MCINTOSH
*1939 MURRAY
*1913 MUSKOGEE
1956 NOBLE
1952 OKFUSKEE
*1906 OKLAHOMA
1969 OKLAHOMA
1968 OKMULGEE
1964 OTTAWA
1959 PAWNEE
*1916 PAYNE
*1937 PITTSBURG
1971 PITTSBURG
*1941 PONTOTOC
1973 PONTOTOC
*1914 ROGER MILLS
1963 ROGER MILLS
1966 ROGERS
1970 SEQUOYAH
1964 STEPHENS
*1930 TEXAS
1961 TEXAS
*1930 TILLMAN
1974 TILLMAN
*1906 TISHOMINGO AREA
*1942 TULSA
1968 WASHINGTON
*1941 WASHITA
1939 WOODS
*1938 WOODWARD
1963 WOODWARD

OREGON

1973 ALSEA AREA
1949 ASTORIA AREA
1954 BAKER AREA
*1903 BAKER CITY AREA
1920 BENTON
1975 BENTON
*1921 CLACKAMAS
1929 COLUMBIA
1970 CURRY AREA
1958 DESCHUTES AREA
1925 EUGENE AREA
1926 GRANDE RONDE VALLEY AREA
*1912 HOOD RIVER-WHITE SALMON RIVER AREA
1919 JOSEPHINE
*1908 KLAMATH RECLAMATION PROJECT
1924 LINN
*1927 MARION
1972 MARION
*1909 MARSHFIELD AREA
*1911 MEDFORD AREA
*1919 MULTNOMAH
1922 POLK
1966 PRINEVILLE AREA
*1903 SALEM AREA
1964 SHERMAN
1973 SOUTH UMPQUA AREA
1964 TILLAMOOK AREA
1975 TROUT CREEK-SHANIKO AREA
1948 UMATILLA AREA
*1919 WASHINGTON
*1917 YAMHILL AREA
1974 YAMHILL AREA

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PENNSYLVANIA

*1904 ADAMS
1967 ADAMS
*1939 ARMSTRONG
*1911 BEDFORD
*1909 BERKS
1970 BERKS
*1915 BLAIR
*1911 BRADFORD
*1946 BUCKS
1975 BUCKS AND PHILADELPHIA
*1915 CAMBRIA
1962 CARBON
*1907 CENTRE
*1905 CHESTER
1963 CHESTER AND DELAWARE
1958 CLARION
*1916 CLEARFIELD
1966 CLINTON
1967 COLUMBIA
1954 CRAWFORD
1972 DAUPHIN
*1910 ERIE
1960 ERIE
1973 FAYETTE
*1938 FRANKLIN
1975 FRANKLIN
1969 FULTON
*1921 GREENE
*1944 HUNTINGDON
*1931 INDIANA
1968 INDIANA
1964 JEFFERSON
*1907 JOHNSTOWN AREA
*1914 LANCASTER
1959 LANCASTER
*1900 LANCASTER AREA
*1901 LEBANON AREA
*1912 LEHIGH
1963 LEHIGH
*1903 LOCKHAVEN AREA
*1923 LYCOMING
*1917 MERCER
1971 MERCER
*1905 MONTGOMERY
1967 MONTGOMERY
1955 MONTOUR AND NORTHUMBERLAND
1974 NORTHAMPTON
1969 PIKE
1958 POTTER
*1908 RECONNAISSANCE NORTHWESTERN
*1909 RECONNAISSANCE SOUTHWESTERN
*1910 RECONNAISSANCE SOUTH CENTRAL
*1911 RECONNAISSANCE NORTHEASTERN
*1912 RECONNAISSANCE SOUTHEASTERN
1973 SUSQUEHANNA
*1929 TIOGA
*1946 UNION
1975 VENANGO
*1910 WASHINGTON
*1938 WAYNE
1968 WESTMORELAND
*1929 WYOMING
*1912 YORK
1963 YORK

PUERTO RICO

*1902 ARECIBO TO PONCE
1965 LAJAS VALLEY AREA
1975 MAYAGUEZE AREA OF WESTERN PUERTO RICO
1942 PUERTO RICO

RHODE ISLAND

*1939 KENT AND WASHINGTON
*1942 NEWPORT AND BRISTOL
*1943 PROVIDENCE
*1904 RECONNAISSANCE OF RHODE ISLAND

SOUTH CAROLINA

1937 ABBEVILLE
*1902 ABBEVILLE AREA
*1909 ANDERSON
*1913 BAMBERG
1966 BAMBERG
*1912 BARNWELL
*1916 BERKELEY
1963 CALHOUN
*1903 CAMPOBELLO AREA
1971 CHARLESTON
*1904 CHARLESTON AREA
*1905 CHEROKEE
1962 CHEROKEE
*1912 CHESTER
*1914 CHESTERFIELD
*1910 CLARENDON
*1909 CONWAY AREA
1960 DARLINGTON
*1902 DARLINGTON AREA
1931 DILLON
*1915 DORCHESTER
1938 EDGEFIELD
*1911 FAIRFIELD
*1914 FLORENCE
1974 FLORENCE AND SUMTER
*1911 GEORGETOWN
*1921 GREENVILLE
1975 GREENVILLE
1929 GREENWOOD
*1915 HAMPTON
*1918 HORRY
1919 KERSHAW
*1904 LANCASTER
1973 LANCASTER
1975 LAURENS AND UNION
*1907 LEE
1963 LEE
*1922 LEXINGTON
*1917 MARLBORO
1965 MARLBORO
*1918 NEWBERRY
1960 NEWBERRY
*1907 OCONEE
1963 OCONEE
*1913 ORANGEBURG
*1904 ORANGEBURG AREA
1943 PICKENS
1972 PICKENS
*1916 RICHLAND
*1909 SALUDA
1962 SALUDA
*1921 SPARTANBURG
1968 SPARTANBURG
*1907 SUMTER
1943 SUMTER
*1913 UNION
1928 WILLIAMSBURG
*1905 YORK
1965 YORK

SOUTH DAKOTA

*1920 BEADLE
*1907 BELLEFOURCHE AREA
1971 BENNETT
1959 BROOKINGS
*1903 BROOKINGS AREA
*1925 BROWN
1966 CODINGTON
1974 DAVISON
*1923 DOUGLAS
1922 GRANT
1963 HAND
1975 HUGHES
*1925 HYDE
1973 LAKE
1975 MARSHALL
*1921 MCCOOK
1975 MELLETTE
1964 MINNEHAHA
*1926 MOODY
*1909 RECONNAISSANCE WESTERN SOUTH DAKOTA
1971 SHANNON
1975 SULLY
1974 TODD
1921 UNION
*1923 WALWORTH
1969 WASHABAUGH

TENNESSEE

1947 BEDFORD
1953 BENTON
1959 BLOUNT
1958 BRADLEY
1953 CARTER
1948 CLAIBORNE
1955 COCKE
*1908 COFFEE
1959 COFFEE
1950 CUMBERLAND
*1903 DAVIDSON
1955 DECATUR
1972 DEKALB
*1923 DICKSON
1965 DYER
1964 FAYETTE
1958 FRANKLIN
*1907 GILES
1968 GILES
*1906 GRAINGER
1948 GRAINGER
1958 GREENE
*1904 GREENEVILLE AREA
1946 HAMBLEN
1947 HAMILTON
*1926 HARDIN
1963 HARDIN
*1905 HENDERSON
1960 HENDERSON
*1922 HENRY
1958 HENRY
1958 HOUSTON
1946 HUMPHREYS
*1913 JACKSON
1941 JEFFERSON
1956 JOHNSON
1955 KNOX
1969 LAKE
*1904 LAWRENCE
1959 LAWRENCE
1946 LINCOLN
1961 LOUDON
*1906 MADISON
1958 MARION
*1923 MAURY
1959 MAURY

* OUT OF PRINT : NOT AVAILABLE FOR DISTRIBUTION

1957 MCMINN
*1919 MEIGS
1974 MEIGS
*1901 MONTGOMERY
1975 MONTGOMERY
1953 NORRIS AREA
1973 OBION
*1908 OVERTON
*1953 PERRY
*1903 PIKEVILLE AREA
*1912 PUTNAM
1963 PUTNAM
1948 RHEA
1942 ROANE
*1912 ROBERTSON
1968 ROBERTSON
1956 SEVIER
*1916 SHELBY
1970 SHELBY
1953 STEWART
1953 SULLIVAN
*1909 SUMNER
1967 WARREN
1958 WASHINGTON
1964 WILLIAMSON

TEXAS

*1904 ANDERSON
1975 ANDERSON
1974 ANDREWS
*1912 ARCHER
1965 ARMSTRONG
*1904 AUSTIN AREA
1963 BAILEY
*1907 BASTROP
*1938 BEE
*1916 BELL
1966 BEXAR
1975 BORDEN
*1918 BOWIE
*1902 BRAZORIA AREA
*1914 BRAZOS
*1958 BRAZOS
*1948 BROWN
*1907 BROWNSVILLE AREA
*1941 CAMERON
*1908 CAMP
1962 CARSON
*1937 CASS
1974 CASTRO
*1959 CHEROKEE
1963 CHILDRESS
1964 COCHRAN
1974 COKE
*1922 COLEMAN
1974 COLEMAN
*1930 COLLIN
1969 COLLIN
1973 COLLINGSWORTH
*1907 COOPER AREA
*1908 CORPUS CHRISTI AREA
1974 COTTEL
1966 CROSBY
1975 DALLAM
*1920 DALLAS
1960 DAWSON
1968 DEAF SMITH
*1918 DENTON
*1922 DICKENS
1970 DICKENS
*1943 DIMMIT
*1916 EASTLAND
1971 EL PASO
*1910 ELLIS
1964 ELLIS
*1920 ERATH
1973 ERATH
*1932 FALLS
*1946 FANNIN
1966 FISHER
1964 FOARD
1960 FORT BEND
*1908 FRANKLIN
*1918 FREESTONE
*1929 FRIO
1965 GAINES
*1930 GALVESTON
1975 GARZA
1975 GILLESPIE
1966 GRAY
*1909 GRAYSON
1974 HALE
1967 HALL
1960 HANSFORD
*1932 HARDEMAN
1972 HARDEMAN
*1922 HARRIS
*1912 HARRISON
1961 HASKELL
1974 HEMPHILL
*1906 HENDERSON
*1923 HENDERSON
*1925 HIDALGO
1965 HOCKLEY
*1905 HOUSTON
1969 HOWARD
*1939 HUNT
*1903 JACKSONVILLE AREA
*1913 JEFFERSON
1965 JEFFERSON
1974 JIM HOGG
1972 JONES
*1940 KAUFMAN
1973 KENT
1967 KINNEY
1962 LAMB
*1906 LAREDO AREA
*1905 LAVACA
*1905 LEE
1975 LIPSCOMB
*1917 LUBBOCK
*1903 LUFKIN AREA
1959 LYNN
1975 MARTIN
*1942 MAVERICK
1974 MCCULLOCH
1958 MCLENNAN
1967 MENARD
*1928 MIDLAND
1973 MIDLAND
*1925 MILAM
1969 MITCHELL
1972 MONTGOMERY
1975 MOORE
*1909 MORRIS
*1925 NACOGDOCHES
*1903 NACOGDOCHES AREA
*1926 NAVARRO
1975 NAVARRO
1965 NUECES
1973 OCHILTREE
1975 PANOLA
*1903 PARIS AREA
*1930 POLK
*1929 POTTER
*1930 RANDALL
1970 RANDALL
*1910 RECONNAISSANCE CENTRAL GULF COAST
*1919 RECONNAISSANCE NORTHWEST
*1910 RECONNAISSANCE PANHANDLE
*1909 RECONNAISSANCE SOUTH
*1913 RECONNAISSANCE SOUTH CENTRAL
*1911 RECONNAISSANCE SOUTHWEST
*1928 RECONNAISSANCE TRANS-PECOS AREA
*1922 RECONNAISSANCE WEST CENTRAL
*1919 RED RIVER
*1922 REEVES
*1907 ROBERTSON
*1923 ROCKWALL
1970 RUNNELS
*1904 SAN ANTONIO AREA
*1906 SAN MARCOS AREA
*1916 SAN SABA
*1931 SCURRY
1973 SCURRY
1975 SHERMAN
*1915 SMITH
1972 STARR
1975 STONEWALL
1968 SUTTON
1974 SWISHER
*1920 TARRANT
*1915 TAYLOR
1974 TERRELL
1962 TERRY
*1931 THE SOILS OF TEXAS
*1909 TITUS
1974 TRAVIS
*1928 VAN ZANDT
*1902 VERNON AREA
*1927 VICTORIA
*1905 WACO AREA
1975 WARD
*1913 WASHINGTON
1974 WHARTON
*1932 WHEELER
1975 WHEELER
1962 WIBARGER
*1924 WICHITA
*1926 WILLACY
*1938 WILLIAMSON
*1901 WILLIS AREA
*1907 WILSON
*1903 WOODVILLE AREA
*1964 YOAKUM
*1940 ZAVALA

UTAH

*1920 ASHLEY VALLEY AREA
*1904 BEAR RIVER AREA
1960 BERYL-ENTERPRISE AREA
1975 BOX ELDER
*1913 CACHE VALLEY AREA
1974 CACHE VALLEY AREA
1970 CARBON-EMERY AREA
1968 DAVIS-WEBER
*1919 DELTA AREA
*1959 EAST MILLARD AREA
*1939 PRICE AREA
*1903 PROVO AREA
*1899 RECONNAISSANCE SANPETE, CACHE, AND UTAH
1958 RICHFIELD AREA
*1959 ROOSEVELT-DUCHESNE AREA
1946 SALT LAKE AREA
1974 SALT LAKE AREA
*1899 SALT LAKE VALLEY AREA
1962 SAN JUAN AREA
*1900 SEVIER VALLEY AREA
*1921 UINTA RIVER VALLEY AREA
1972 UTAH(CENTRAL PART)
*1942 VIRGIN RIVER VALLEY AREA
*1900 WEBER AREA

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VERMONT

1971 ADDISON
1974 CHITTENDEN
1959 GRAND ISLE
*1937 RECONNAISSANCE OF ENTIRE STATE
*1904 VERGENNES AREA
*1916 WINDSOR

VIRGINIA

*1917 ACCOMACK AND NORTHAMPTON
*1940 ALBERMARLE
*1902 ALBERMARLE AREA
*1904 APPOMATTOX
*1937 AUGUSTA
*1901 BEDFORD AREA
1954 BLAND
*1909 CAMPBELL
1967 CARROLL
1974 CHARLOTTE
*1906 CHESTERFIELD
*1952 CULPEPER
1963 FAIRFAX
*1915 FAIRFAX AND ALEXANDRIA
1956 FAUQUIER
1958 FLUVANNA
*1914 FREDERICK
*1930 GRAYSON
1938 HALIFAX
*1905 HANOVER
*1914 HENRICO
1975 HENRICO
1941 ISLE OF WIGHT
1953 LEE
*1903 LEESBURG AREA
1960 LOUDOUN
*1905 LOUISA
1975 MADISON
1962 MATHEWS
1956 MECKLENBURG
*1907 MONTGOMERY
*1932 NANSEMOND
*1903 NORFOLK AREA
1959 NORFOLK AREA
1963 NORTHUMBERLAND AND LANCASTER
1960 NOTTOWAY
*1927 ORANGE
1971 ORANGE
*1918 PITTSYLVANIA
1958 PRINCE EDWARD
*1901 PRINCE EDWARD AREA
1945 PRINCESS ANNE AREA
1961 RAPPAHANNOCK
*1931 ROCKBRIDGE
1945 RUSSELL
1951 SCOTT
*1948 SMYTH
*1937 SOUTHAMPTON
1974 STAFFORD AND KING GEORGE
1948 TAZEWELL
1945 WASHINGTON
1954 WISE
*1905 YORKTOWN AREA

VIRGIN ISLANDS

1932 RECONNAISSANCE OF ST. CROIX ISLAND
1970 VIRGIN ISLANDS OF THE U.S.

WASHINGTON

1967 ADAMS
*1907 BELLINGHAM
*1916 BENTON
1971 BENTON
1975 CHELAN AREA
1951 CLALLAM
1972 CLARK
1973 COLUMBIA AREA
1974 COWLITZ AREA
*1905 EVERETT AREA
*1914 FRANKLIN
1974 GARFIELD AREA
*1912 HOOD-RIVER WHITE SALMON AREA
*1905 ISLAND
1958 ISLAND
1975 JEFFERSON AREA
1952 KING
1973 KING AREA
*1939 KITSAP
1945 KITTITAS
1954 LEWIS
1960 MASON
1955 PIERCE
*1911 QUINCY AREA
*1911 RECONNAISSANCE SOUTHWESTERN
1929 RECONNAISSANCE COLUMBIA BASIN AREA
*1909 RECONNAISSANCE EASTERN PART PUGET SOUND BASIN
*1910 RECONNAISSANCE WEST PART OF PUGET SOUND BASIN
1962 SAN JUAN
1960 SKAGIT
1956 SKAMANIA
1947 SNOHOMISH
1917 SPOKANE
1968 SPOKANE
*1913 STEVENS
1958 THURSTON
1964 WALLA WALLA
*1902 WALLA WALLA AREA
*1918 WENATCHEE AREA
1953 WHATCOM
1958 YAKIMA
*1901 YAKIMA AREA

WEST VIRGINIA

1968 BARBOUR
*1917 BARBOUR AND UPSHUR
1966 BERKELEY
*1913 BOONE
*1918 BRAXTON AND CLAY
1974 BROOKE, HANCOCK AND OHIO
*1910 CLARKSBURG AREA
*1919 FAYETTE
1975 FAYETTE AND RALEIGH
*1922 GRANT AND MINERAL
1941 GREENBRIER
1972 GREENBRIER
*1927 HAMPSHIRE
*1930 HARDY AND PENDLETON
*1911 HUNTINGTON AREA
1961 JACKSON AND MASON
1973 JEFFERSON
*1916 JEFFERSON, BERKELEY, AND MORGAN
*1912 KANAWHA
*1915 LEWIS AND GILMER
*1913 LOGAN AND MINGO
1960 MARSHALL
*1914 MCDOWELL AND WYOMING
*1923 MERCER
*1907 MIDDLEBOURNE AREA
*1925 MONROE
1965 MONROE
*1911 MORGANTOWN AREA
*1920 NICHOLAS
*1908 PARKERSBURG AREA
*1938 POCAHONTAS
*1910 POINT PLEASANT AREA
*1912 PRESTON
1959 PRESTON
*1914 RALEIGH
*1931 RANDOLPH
*1909 SPENCER AREA
*1924 SUMMERS
*1921 TUCKER
1967 TUCKER-RANDOLPH
*1905 UPSHUR
*1918 WEBSTER
*1906 WHEELING AREA
1970 WOOD AND WIRT

WISCONSIN

*1920 ADAMS
1958 BARRON
*1910 BAYFIELD
1961 BAYFIELD
*1929 BROWN
1974 BROWN
*1913 BUFFALO
1962 BUFFALO
*1925 CALUMET
*1911 COLUMBIA
*1930 CRAWFORD
1961 CRAWFORD
*1913 DANE
*1916 DOOR
1975 DUNN
*1911 FOND DU LAC
1973 FOND DU LAC
1961 GRANT
*1922 GREEN
1974 GREEN
1922 GREEN LAKE
*1910 IOWA
1962 IOWA
*1918 JACKSON
*1902 JANESVILLE AREA
*1912 JEFFERSON
*1911 JUNEAU
*1919 KENOSHA AND RACINE
1970 KENOSHA AND RACINE
*1911 KEWAUNEE
*1911 LA CROSSE
1960 LA CROSSE
1966 LAFAYETTE
*1926 MANITOWOC
1975 MARQUETTE
*1916 MILWAUKEE
1971 MILWAUKEE AND WAUKESHA
*1923 MONROE
*1918 OUTAGAMIE
1970 OZAUKEE
1964 PEPIN
*1923 PIERCE
1968 PIERCE
*1905 PORTAGE
*1915 PORTAGE
*1906 RACINE
*1913 RECONNAISSANCE NORTHEASTERN
*1909 RECONNAISSANCE MARINETTE
*1914 RECONNAISSANCE NORTH PART OF NORTHWESTERN
*1914 RECONNAISSANCE NORTH PART OF NORTH CENTRAL
*1915 RECONNAISSANCE SOUTH PART OF NORTH CENTRAL
1959 RICHLAND

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*1917 ROCK
1974 ROCK
*1925 SAUK
*1924 SHEBOYGAN
*1904 SUPERIOR AREA
*1927 TREMPEALEAU
*1928 VERNON
1969 VERNON
*1903 VIROQUA AREA
*1920 WALWORTH
1971 WALWORTH
1971 WASHINGTON
*1921 WASHINGTON AND OZAUKEE
*1910 WAUKESHA
*1917 WAUPACA
*1909 WAUSHARA
*1927 WINNEBAGO
*1915 WOOD

WYOMING

*1928 BASIN AREA
1955 CAMPBELL
*1917 FORT LARAMIE AREA
1971 GOSHEN(SOUTHERN PART)
1939 JOHNSON
1975 JOHNSON
*1903 LARAMIE AREA
1974 RIVERTON AREA
1939 SHERIDAN
*1927 SHOSHONE AREA
1969 TETON AREA IDAHO-WYOMING
1940 UINTA
*1926 WHEATLAND AREA

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Soil Survey Publications

A total of 101 soil surveys were edited and sent to the Government Printing Office during fiscal year 1976. Soil surveys for the following 88 counties or soil survey areas were published and distributed in fiscal year 1976.

Alabama
- Escambia County

Arizona
- Apache Area, Arizona
  - Central Part
- Wilcox Area
- Yavapai County, Arizona,
  - Western Part

Arkansas
- Howard County
- Pulaski County

California
- Nevada County Area
- Sierra County

Caribbean Area
- Mayaguez Area of
  - Western Puerto Rico

Colorado
- Chaffee-Lake Area, Colorado
  - Parts of Chaffee and Lake Counties
- Gunnison Area

District of Columbia

Florida
- Holmes County
- Ocala National Forest Area,
  - Parts of Marion, Lake, and Putnam Counties

Georgia
- Colquitt and Cook Counties
- Miller and Seminole Counties

Idaho
- Payette County

Illinois
- Pope, Hardin, and
  - Massac Counties

Indiana
- Jennings County
- Crawford County

Iowa
- Fremont
- Linn
- Madison County
- Mitchell County
- Plymouth County
- Worth County

Kansas
- Ellis County
- Riley and Geary Counties

Kentucky
- Ballard and McCracken Counties

Maryland
- Baltimore County
- Harford County Area

Minnesota
- Nobles County
- Pipestone County

Mississippi
- Amite County
- Harrison County
- Jefferson Davis County
- Lamar County
- Montgomery County

Missouri
- Henry County
- Scotland County

Montana
- Dawson County

Nebraska
- Cuming County
- Douglas and Sarpy Counties
- Dakota County
- Pawnee County

New Jersey
- Passaic County
- Sussex County

New Mexico
- Mescalero-Apache Area, Northeastern Otero County
- Sante Fe Area
- White Sands Missile Range, Parts of Dona Ana, Lincoln, Otero, Sierra, and Socorro Counties

New York
- Washington County

North Carolina
- Catawba County

North Dakota
- Bowman County
- Oliver County
- Richland County, and Sheyenne National Grassland Area of Ransom County

Ohio
- Clermont County
- Richland County
- Union County

Oklahoma
- Haskell County
- Mayes County

Oregon
- Benton County

Pennsylvania
- Bucks and Philadelphia County
- Franklin County
- Venango County

South Carolina
- Greenville County
- Lexington County

South Dakota
- Marshall County

Tennessee
- Montgomery County

Texas
- Anderson County
- Borden County
- Chambers County
- Garza County
- Lipscomb County
- Panola County
- Sherman County
- Uvalde County
- Wheeler County

Utah
- Beaver-Cove Fort Area
- Box Elder County, Eastern Part
- Heber Valley Area, Parts of Wasatch and Utah Counties

Virginia
- Henrico County
- Louisa County
- Madison County

Washington
- Yakima Indian Reservation Irrigated Area, Part of Yakima County
- Jefferson County Area

Wisconsin
- Marquette County

Wyoming
- Johnson County, Southern Part
- Star Valley Area, Wyoming-Idaho Parts of Lincoln County, Wyoming, and Bonneville and Caribou Counties, Idaho

Soil surveys published thus far in Fiscal Year 1977:

October

1. Harris County, Texas
2. Pierce County, Nebraska
3. Baldwin, Jones, and Putnam Counties, Ga.
4. Morris County, New Jersey

November

5. Cloud County, Kansas
6. Chautauqua County, Kansas
7. Canadian County, Oklahoma

December

8. Baylor County, Texas
9. Hutchinson County, Texas

January

10. Trempealeau County, Wisconsin
11. Somerset County, New Jersey
12. Drew County, Arkansas
13. Tom Green County, Texas

February

14. Onondaga County, New York
15. Allegany County, Maryland
16. Wood County, Wisconsin
17. Goodhue County, Minnesota
18. Taylor County, Texas

March

19. Meadow Valley Area, Nevada-Utah
20. Geneva County, Alabama
21. Osborne County, Kansas
22. Benton County, Arkansas
23. Ness County, Kansas
24. Barnwell County, South Carolina (Eastern Part)

April

25. Appanoose County, Iowa
26. Red River County, Texas
27. Benton County, Minnesota
28. Lenoir County, North Carolina

Published but holding for correction:

29. Clay Co., Miss.
30. Woodson Co., Kansas
31. Palo Alto Co., Iowa

Not Published, but should have been published by the end of March (according to target dates on CASPUSS). The date in parentheses shows when sent for printing and binding:

32. Benton, MS (10/76)
33. Grundy, IA (11/76)
34. Barber Co., KS (11/76)
35. Leavenworth, KS (11/76)
36. Cape May, NJ (11/76)
37. Armstrong, PA (11/76)
38. Fort Hall Area, ID (11/76)
39. Mahaska, IA (11/76)
40. Eddy Co., ND (12/76)
*41. Bandera, TX (1/77)
42. Bell, TX (11/76)
43. Humacao, P.R. (11/76)
*44. Sheridan, MT (1/77)
45. Dawes, NB (11/76)
*46. Washington, OH (1/77)
47. Campbell, VA (12/76)

*Allowing a minimum of 12 weeks for printing and binding, these surveys are not due for publication until the last of April. The target date on CASPUSS will be changed.

ACKNOWLEDGEMENTS

The development of this program and the preparation of the modules resulted from the collaboration of many individuals in the College of Agriculture and Life Sciences, a statutory unit of the State University at Cornell University, and others. The primary faculty and staff associated with the project were:

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This program was supported in part by grant T-900500 from the Academic Training Section, U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers.

The current modules are based on modules developed during the initial phase of this project (1974-1976). Other personnel involved with writing or editing initial modules of the program included:

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M. M. Bogin edited copy and contributed to written and audio-tutorial modules. S. M. Dabney was the primary author of the Crop Selection and Non-crop and Forest Systems modules.

J.K. Krizek, A.L. Liebermann and R.H. Nagell contributed art work and graphic design. L.A. Martin, A.C. Plescia, B.C. Littlefair and others provided secretarial assistance. D.P. Willmot prepared and processed audio-tutorial materials. Audio-tutorial program was narrated by K. Marash.

Other faculty assistance was provided by W.H. Allaway, D.R. Bouldin, D.J. Lathwell, G.W. Olson, and P.J. Zwerman. Technical assistance of various kinds was provided by R. Batkin, S. Haeni, W. Messner, D. Payne, D. Way, G. MacCaskill, and D. Krizek. Thanks are also due to many other members of the Cornell community who shared time, ideas, and materials.

Personnel of the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory, Hanover, N.H. and Office of the Chief of Engineers in Washington, D.C. reviewed the written and audio-tutorial modules. The audio-tutorial modules were also reviewed at the National Training and Operational Technological Center of the Environmental Protection Agency, Cincinnati, Ohio.

State environmental regulatory agencies provided land application guidelines. Many other individuals, companies, and federal agencies provided technical information, comments, and visual materials. Their generosity has made a major contribution to the program.

SITE EVALUATION: GENERAL CRITERIA - INFORMATION SOURCES

Objectives

Upon completion of this module, the participant should be able to:

1. List the general categories of information which can be found in a soil survey that relate to evaluation of a waste treatment site.

2. Describe the general climatic conditions in his or her zone of the United States.

3. List the sources of topographic maps and hydrogeologic studies and describe how to apply the information contained therein.

4. Summarize the criteria discussed in this module by which a potential site is judged.

RETURN TO
LESSON PACKAGE

Script to Accompany the A-T

SITE EVALUATION: GENERAL CRITERIA -
INFORMATION SOURCES

C2

Module 2

January, 1978

SITE EVALUATION: GENERAL CRITERIA - INFORMATION SOURCES

The feasibility of land application and treatment of wastes rests on the integration of many considerations (Slide 1). A number of these considerations are listed in Slide 2. This module is directed to evaluating those characteristics of the land area that affect the treatment of wastewater and sludge. The objectives for this lesson are located in an envelope that was with the module material. Find the envelope and study the objectives (Slide 3). You may keep the objectives for reference during the lesson.

The particular considerations that enter into a selection of a site are indicated in Slide 4. They will be considered under the four main categories - climate and weather, land use, topography, and geology and soils. Very general information about these topics will be discussed in this lesson and sources of information for specific areas of the country will be stressed.

Localized areas provide little choice with respect to climatic conditions (Slide 5). Nevertheless, climate strongly affects the overall feasibility as well as the ultimate design of land treatment systems.

Broad relationships between climate and waste application systems are shown in a generalized climatic map in Slide 6. The depicted zones are useful for preliminary planning, but ordinarily a detailed analysis of localized climatological data is needed for design purposes. The slide can be used to indicate the main climatological factor that must be considered when designing a land treatment site in each of these areas.

Zone A (Slide 7) covering much of California, has generally mild to hot temperatures throughout the year. With irrigation, plant growth can be continuous. Zone B includes the arid areas of the southwest. In both zones, land application of wastes is possible year-round. Storage of effluent, however, may be desirable in these areas to satisfy crop needs which are greater in the warm than the cooler months.

Zone C (Slide 8) indicates areas that also can utilize land application year-round. The main limitation for land treatment in these areas is saturated soil conditions, since they receive about 40 to 60 inches of precipitation a year. There may also be a few times during the year when operations must be limited due to cold.

As Slide 9 indicates, in Zone D and E the main limitation to land application is cold weather. In Zone D storage of wastewater may be necessary for up to three months and in Zone E a six month storage period may have to be planned.

Although winter storage is an added concern, it is not as restrictive, economically, as might be expected. Data on the costs of storage can be found in written Module 10, "Costing Land Application Systems" (Slide 10). Different types of application systems require differing amounts of storage for the same weather conditions. Information on this aspect can be found in Module 8, "Climate and Wastewater Storage".

Climatic data for most locations in the U.S. are available from various publications of the National Oceanic and Atmospheric Administration (NOAA) and SCS soil surveys (Slide 11). Monthly summaries of climatic data provides useful information on several climatic variables including total precipitation, maximum and minimum temperatures, and relative humidity values for every weather station in a given area. Evaporation data are included where available. In the climatic summary of the U.S. (Slide 12), climatic data for each weather station in a given area are summarized for a 10 year period. Specific information includes those variables indicated in Slide 12. The precipitation, temperature, and snowfall information are important for the planning of application and storage periods.

Another source of climatological information can be found in the County Soil Surveys published by the Soil Conservation Service (Slide 13). The survey for each county presents a summary of the climate for a particular county in both narrative and tabular form. The soil surveys are also a major source of information for other factors that influence the planning and design of a land treatment facility and they will be discussed in detail later in this module. Storage Requirement Computations were recently developed in a computer program through the National Climatic Center in Asheville, North Carolina. Three versions are now available which utilize daily climatic data from over a period of years to identify the number of favorable and unfavorable days for waste application. Slide 14 indicates the variables that are considered in these programs. From this analysis, storage requirements can be calculated. Module 8, "Climate and Wastewater Storage" provides additional information on this source.

Knowledge of current land use in an area indicates how much land is potentially suitable and/or available for waste application (Slide 15). For example, agricultural land can often serve or at least be adapted for use in waste treatment. Abandoned farmland and forestland may also be suitable. A cursory review of land use maps like the one shown in Slide 16 or an aerial photograph can avoid consideration of areas with urban or industrial development, historical values, or unique environmental features. Planning agencies at local, state, and/or regional levels can usually supply pertinent information on land use. Both current and projected land use patterns are helpful in evaluating the area. Available information, however, varies widely in terms of specificity. Occasionally, the possible site will be limited to land already owned by a municipality or industrial concern. In such cases, the uses of the land surrounding the site should be evaluated to determine if these uses are compatible with a waste application system (Slide 17). Projected land use plans, where they exist, may also eliminate certain areas from consideration.

A number of states, New York being a prime example, have developed land use information that is very detailed. New York provides information on 130 categories of land use for all areas of the state. Data are available in the three forms indicated in Slide 18. The computerized format allows for the addition of supplemental information. Currently included with the computerized format is a geology map, a generalized soil map, and a map of economic viability of farm areas in the state.

The overall configuration of the landscape determines the pathway and rate of surface water movement and often the subsurface flow (Slide 19). As such, topography affects how well the site will handle water and the extent of contact between constituents and soil particles. Slide 20 indicates the influence that topography may exert on a land application site. Except on very permeable soils, steep slopes increase the possibility of rapid surface runoff. Unchecked runoff can short-circuit the renovation process and may erode the soil as well.

The United States Geological Survey publishes topographic maps for many areas in 7.5 and/or 15 minute series. These maps are usually at scales of 1:62,500 or 1:24,000. Standard topographic maps are useful in describing the location of potential sites and in determining topographic

variations, distance from waste sources, proximity to surface waters and to population centers, and in some cases current land use and groundwater discharge areas. An example of a topographic map is shown in Slide 21. Notice the topography of the proposed land application site and the area around the site. Slopes are gentle with little potential for runoff onto or off the site. The handout that accompanied this module gives the addresses of sources for these topographic maps.

There are no uniform regulations relating slope and waste application. The so-called Ten States Standards for the Great Lakes Upper Mississippi River Basin are an example of the generally conservative regulations that have been proposed as limits for sprinkler irrigation. These guidelines are summarized in Slide 22. Some experts have suggested that the limit for spray irrigation of cultivated fields and pastures can be as high as 15% slope with higher slopes allowable for forestland.

Slope constraints vary with other application methods. Existing overland flow systems are generally operated on slopes between 2 and 8%. As is indicated in Slide 23, the length of the slope has been found to be limited to 300 feet since that is the maximum for the maintenance of uniform distribution of wastewater. A length of 175 feet was found to be sufficient for food processing wastes at a facility in Paris, Texas.

Examination of topography should not be limited to the slope of potential sites. Local variations in surrounding topography are useful in a preliminary determination of surface and subsurface drainage patterns and to determine if these will affect the smooth operation of a potential land application site. The site indicated in Slide 24, for example, might receive runoff from the adjacent slopes limiting the application of wastewater. The design of a drainage system to prevent this from becoming a problem is discussed in detail in Module 21, "Drainage for Land Application Sites" (Slide 25).

Almost all soil properties affect or are affected by waste application. Practical considerations obviously limit investigation in the preliminary stages of decision making. Here the task is one of evaluating those characteristics which are most restrictive or which best reflect the potential performance of the system. Evaluation is complicated by the fact that no well established guidelines exist. This is especially true

for the overland flow and rapid infiltration methods of wastewater application. Nevertheless, information on the soil properties in Slide 26 are suggested for initial consideration. Site characteristics in relation to those soil properties will be discussed.

The major source of soil information for a particular area can be obtained from soil surveys (Slide 27). Soil surveys have been made and published since 1899. Currently all survey activity is consolidated in the Soil Conservation Service. Soil survey reports include maps showing the distribution of different soils and interpretations for the use of these soils. Although most reports issued prior to about 1960 include interpretative information limited to farming operations, the more recent reports provide ratings and interpretations for many other uses, including engineering applications. As such, soil survey reports constitute a valuable source of information in planning and designing land treatment systems. Although soil information can be obtained through the sources indicated on the sheet that is provided with this module, the discussion will be centered on the information provided in the soil surveys.

Module 3, "Soil as a Treatment Medium", refers to the size and distribution of mineral particles, from fine clays to gravels and cobbles. Texture, indicated in Slide 28, reflects major differences in pore size and permeability as well as the surface area available for interaction with waste constituents. As indicated in Slide 29, medium textured soils ranging from sandy loams to silty clay loams, are generally suitable for effluent irrigation and sludge application. These loamy soils often exhibit the best combination of water handling capabilities and waste renovation potentials. Coarse textured soils such as sands and gravels can accept large quantities of water without runoff, but renovation capabilities are often low. Rapid infiltration systems may be considered where coarse textured subsoils are overlain by medium textured surface layers, thereby increasing the potential for renovation. Fine textured soils, unless well structured, are only suitable for overland flow systems.

The table in Slide 30 indicates other characteristics of the soil that should be considered when planning a land application site. Some of the characteristics of a potential site can be modified by artificial means, such as adding drainage to lower the water table. If soil depth is inadequate, then a lower rate of waste application may be possible. Notice

that overland flow systems require the least effective depth since much of the actual treatment occurs at or very near the surface. Nevertheless, a foot or more of unconsolidated material overlying an impermeable layer will increase the renovation possibilities for waste constituents such as phosphorus and metals, which depend largely on adsorption reactions with soil particles. Some depth is also required for adequate root development of vegetative cover. A copy of this table is with the other printed material obtained earlier in this module.

In all cases the kind and condition of bedrock is of major importance. Fractured or fissured rock allows wastes to move rapidly to groundwater with little opportunity for renovation (Slide 31). This condition is particularly serious with high rate systems or where wastewater or sludge application augment a high natural precipitation. Limestone bedrock is of particular concern since sinkholes may exist, be expanded, or initiated with wastewater application.

Slide 32 is a photograph of a general soil map that is included with a soil survey. The general soil map covers an entire county or more and indicates soil associations. The scale for these is usually about one-half inch to the mile. These maps can be used to get a general idea of the soils in a county or to locate large tracts which may be suitable for certain land use such as waste application. Slide 33 indicates the limitations of general soil maps. The detailed soil maps are used to overcome these limitations.

Detailed maps are usually published at a scale of between 3 to 4 inches to the mile. Slide 34 indicates the categories into which the soils are divided. The soil phases are the basic mapping units used on the detailed soil maps. The detailed portion of a soil map shown in Slide 35 with the accompanying key should help clarify this discussion. You may turn off the recorder to review this slide and the previous slide.

Detailed soil maps offer a greater amount of information than general maps since the mapping units are more refined. Nevertheless, individual named units, as designated on detailed maps, always contain variable amounts of different soils due to limitations of the mapping scale. This is illustrated in Slide 36. For purposes of management interpretations such inclusions of unidentified soils seldom exceed 15% of the area designated by a particular mapping unit. This means that

approximately 85% or more of an area shown on the map as Valois-Howard gravelly loam, will, in fact, consist of Valois-Howard gravelly loam or other soil units which respond similarly to management. The remaining 15%, however, may consist of quite different soils in terms of management interpretations. This slide shows a 10 acre area mapped at the customary scale and at a much smaller scale. At the normal scale the entire area was mapped as a soil complex, Valois-Howard gravelly loam, 8-15% slopes. As can be seen on the smaller scale map, this area is actually made up of five types of soil, some of which have characteristics vastly different than the dominant soil. The minor areas would not be indicated on the detailed soil maps, but could markedly affect the performance of a site. Detailed soil maps are also limited by the depth of soil that they identify, usually four to five feet. Because of these limitations, printed soils information are not a substitute for an on-site visit by a qualified soil scientist before any final design decisions are made (Slide 37).

Descriptions of mapping units for both general and detailed maps are provided in the text of the soil survey. As is shown in Slide 38, the approximate acreage and proportional extent of each unit is given. Each series description has a short narrative describing a representative profile and a much more detailed description of the same profile from which highly technical interpretations can be made. Slide 39 is a photograph of a soil profile. Notice the distinctions between the different layers or horizons. For most soil profiles three horizons, the A, B, and C horizons, are distinguished (Slide 40). The A horizon usually extends from 6 to 16 inches deep. This is the horizon that contains the greatest proportion of organic matter and is the most active biologically (Slide 41). Often the A horizon is referred to as the surface soil. Well decomposed organic matter coats the surface of the mineral particles in the A horizon and is responsible for the characteristic dark color. As wastewater and precipitation travel through the A horizon, soluble material and clay particles are transported to the B horizon. The B horizon is lower in biological activity than the A horizon. When there is a relatively large accumulation of clay, blocky, platy, or prismatic structures can be formed (Slide 42) making this horizon less permeable and more difficult to manage. The B horizon also accumulates the iron, magnesium, potassium, and lime that has leached from the A horizon.

The C horizon is most often the parent material from which the soil was formed. It might, however, consist of other material. It is very low in organic matter and biological activity. The C horizon extends to bedrock. As is shown in Slide 43, these horizons are often subdivided in transitional areas. It is not unusual for one of the horizons to be missing from a soil. The A horizon, for example, might be missing in severely eroded soil. The detailed descriptions of the different soils in a soil survey utilizes the A, B, and C horizons as the basis for description.

In addition to maps and descriptions of soils, soil survey reports contain considerable information on the use and management of soils. A number of these categories are indicated in Slide 44. All of these categories can pertain to the suitability of a potential site for land treatment. Slide 45 indicates the information given on one soil type - Arkport sandy loam. If there were a potential site with this soil predominating, the engineer could consider either a rapid infiltration or an irrigation system for waste application. The potential site, however, would still have to be examined in detail by a soil scientist.

In areas where SCS Soil Surveys have not been made, it is possible to obtain useful geological and soil information from state geological surveys or equivalent state agencies, from state mining industry records and reports, and waterwell drilling records. In many cases the information from these sources may be more up to date than the available soil survey (Slide 46).

The soil survey details much of the information concerning soils and geology (Slide 47). The geological survey, however, is the major source of information concerning water quality and water level. Records of water levels in about 3500 of their 16,000 well observation networks are published in the USGS Water Supply Paper series called Groundwater Levels in the United States for a particular region (Slide 48). This data will be useful in establishing the general groundwater quality in a region.

The geological survey also undertakes project investigations for area groundwater studies, generally in cooperation with local, state or other federal agencies. As can be inferred from Slide 49, these studies can be very useful in planning a land treatment system. Results of these studies

are published either by the USGS in its various publication series or in state reports in cooperation with local agencies.

Air photos are another source of information for locating possible sites for a land application system (Slide 50). The amount of information obtainable from aerial photos is directly related to the experience of the personnel using them. Nevertheless, those without experience can still, with some practice, obtain useful information.

Land use patterns are easily recognized from air and some satellite photographs. Tonal differences and photographic textural changes can serve to delineate forestlands, grasses, various cultivated crops, and bare soil along with urban and suburban areas. The value of this information will depend on how recently the photographs were made and the time of year they were taken (Slide 51). Often, subtle drainage differences that might be quite difficult to detect on the ground can be detected from air photos. In general, however, air photos are best used to compliment rather than replace other information sources.

Air photos commonly occur as oblique photographs, vertical photographs, and/or composite photographs. Oblique photos are taken with the axis of the camera at various angles between the horizon and the ground (Slide 52). They usually cover a larger area than verticals but their usefulness is limited to fairly level terrain where the view is not obstructed by ridges or highlands. Vertical photographs are taken with the aerial camera pointed straight down. Overlapping exposures in each flight line permit the interpreter to study vertical photos three-dimensionally, using a stereoscope. Slide 53 shows a pair of overlapping exposures. Unless otherwise specified, aerial photos are understood to be verticals. Mosaics are composite pictures assembled from individual vertical photos, matched to give the appearance of a single large print. Such mosaics form the base on which detailed soil maps are published. Aerial photographs range in scale from about 1:12,000 to 1:20,000. A scale of 1:20,000 is about the smallest that nonprofessional interpreters can use efficiently. Enlargements can be made, but in general they offer no additional detail and cannot be viewed with simple stereoscopes. Enlargements, however, may present definite advantages in the transfer of photo details to base maps.

In summary, there is a variety of information available to help the operator and designer of the land application system. Persons involved in land treatment should be aware of the sources in order to use this information to their advantage.

SOURCES OF INFORMATION

Land Use

- Local, state, and/or regional planning agencies

Topographic Information

For states east of the Mississippi:

- Branch of Distribution
  U.S. Geological Survey
  1200 Eads Street
  Arlington, Virginia 22202

For states west of the Mississippi:

- Branch of Distribution
  U.S. Geological Survey
  Federal Center
  Denver, Colorado 80225

Soil, Geologic and Drainage Information

- Soil Survey - local or county Soil Conservation Service Office
  County Agents
- U.S. Geological Surveys
- State geological surveys
- State mining industries records and reports
- State universities
- U.S. Army Corps of Engineers District Offices
- Waterwell drillers records

Climatic Data

For monthly summaries of climatic data (for a given area) for local climatological data and climatic summary of the United States:

- National Oceanic and Atmospheric Administration
  Environmental Data Service
  National Climatic Center
  Asheville, North Carolina 28801

Climatic Data (continued)

For storage requirement computations:

- Statistical Climatology Branch
  National Climatic Center
  Asheville, North Carolina 28801

Aerial Photographs:

This office can provide "Status of Aerial Photography in the U.S," which is a key, by county, to the photography that has been done by or for the Agricultural Stabilization and Conservation Service, Soil Conservation Service, Forest Service, Geological Survey, Corps of Engineers, Air Force, Coast and Geodetic Survey, and commercial firms:

- Map Information Office
  U.S. Department of the Interior
  Geological Survey
  Washington, D.C. 20240

Other Information That May Be Helpful

- Summary of Conservation Need Inventory - local Soil Conservation Service Office
  (for county, multi-county area, a state, etc.)

SOIL CHARACTERISTICS FOR LAND APPLICATION OF WASTES

ITEM	SPRAY IRRIGATION	OVERLAND FLOW	RAPID INFILTRATION
Soil type	medium texture soils, silt loam	clay, clay loam	loamy sand to sandy loam
Permeability of the most impermeable subsoil horizon to 60 in. (1.5 m)	moderately rapid to moderate; >0.6 in. (1.5 cm)/hr	very low; <0.2 in. (0.5 cm)/hr	rapid
Infiltration	moderately rapid to moderate	slow-very slow; < 0.2 in. (0.5 cm)/hr	rapid to very rapid; ≥ 1 in. (5 cm)/hr
Soil drainage	moderately well drained	poorly drained	somewhat excessively drained
Soil depth	uniformly > 4-5 feet (1.2-1.5 m)	>1 foot (0.3 m)	>10 feet (3 m)
Available Water Capacity	>6 in. (15 cm)	———	———
Depth to groundwater	>3 ft (0.9 m) to seasonal high groundwater table	>1 foot (0.3 m)	>12 ft (3.6 m) or more